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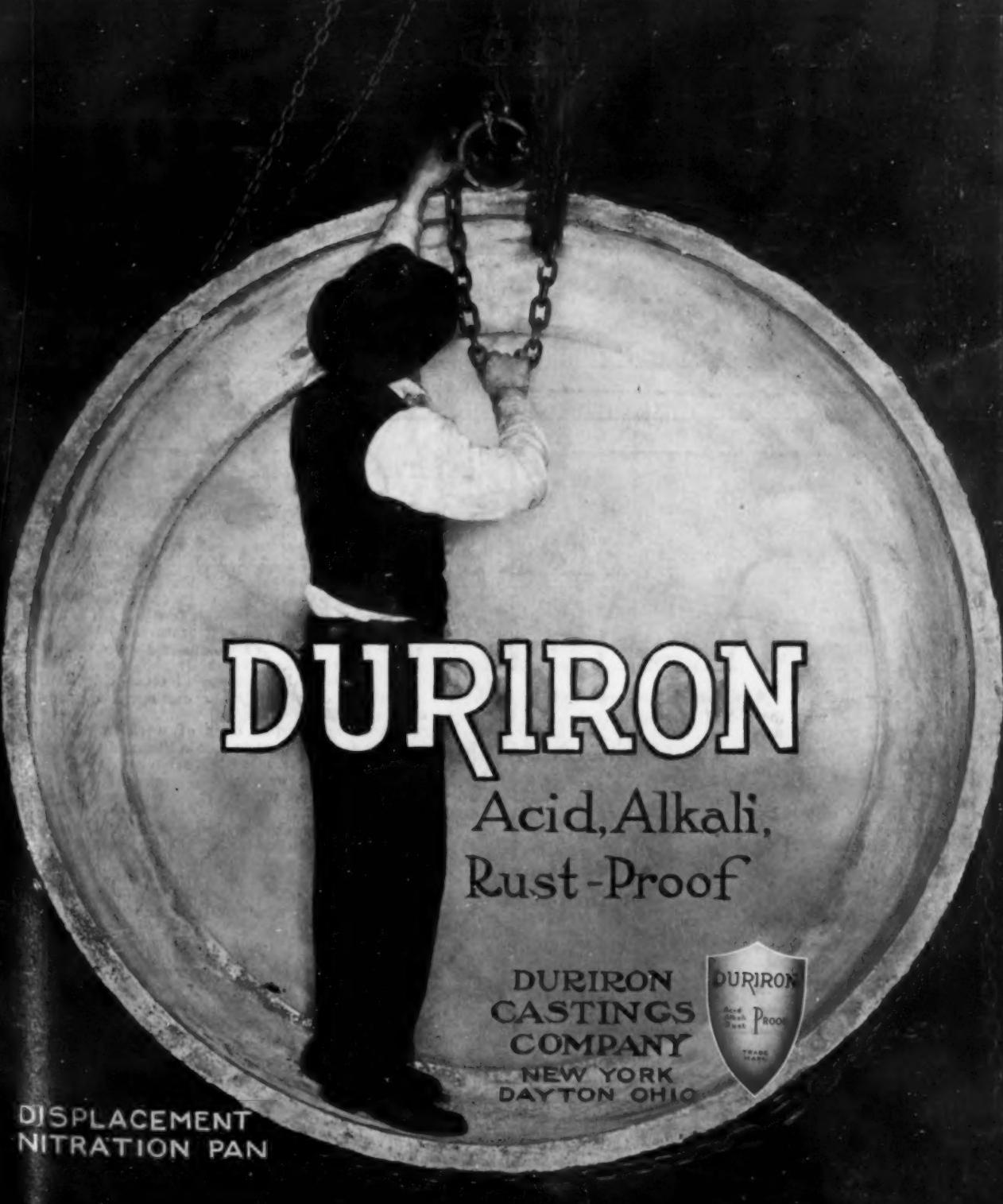
Metallurgical & Chemical Engineering

New York, October 1, 1916

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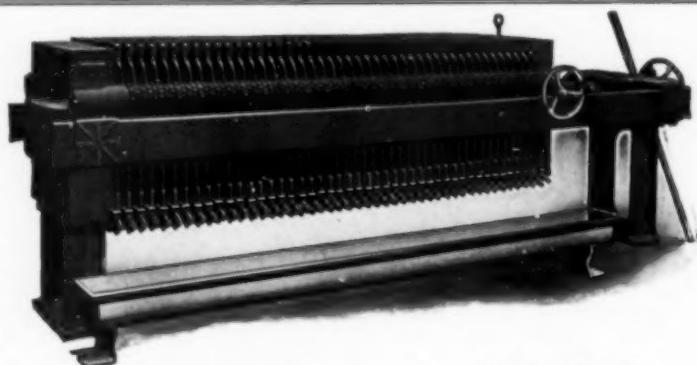
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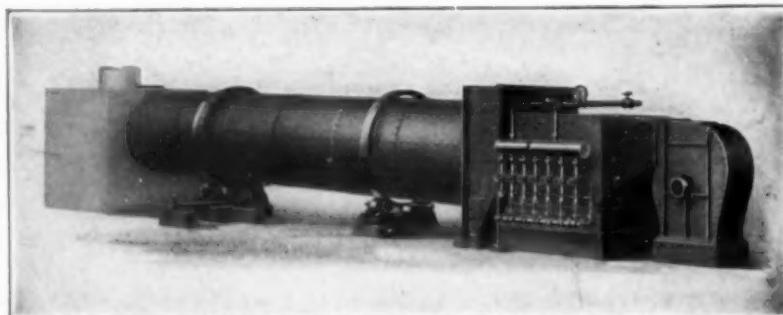
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Metallurgical and Chemical Engineering

A Consolidation of
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The Meaning of Chemical Convocation Week

John Muir, in his Mountains of California, says of the wild sheep of the Sierra Nevada that "each one of the flock, while following the guidance of the most experienced, yet climbs with intelligent independence as a perfect individual. The domestic sheep is only a fraction of an animal, a whole flock being required to form an individual, just as numerous flowerets are required to make one complete sunflower." This expresses clearly the difference between the pioneer and the descendant.

But the necessity for pioneer work never ceases. It only shifts with the progress of civilization to new sets of men, as new fundamental problems develop. The prospector and the mining engineer are the first pioneers of civilization. The civil engineer, building roads and bridges, follows, to be followed again by mechanical and electrical engineers and so on. In this procession of engineers the chemical engineer comes last, because his work presupposes the existence of a civilization so highly developed that waste goes on to such an extent and in so many different lines as to cry out loudly for the necessity of a complete change. Here the work of the chemical engineer sets in. It is his task to change waste into new sources of production. He is a true pioneer and a true creator. Now the psychological moment has come for the chemical engineer to take his proper place in this country. The chemical engineer is to be the pioneer of the next generation.

During the past week we have had in New York City the biggest gathering of chemists this country has ever seen with the only exception of the International Congress of Applied Chemistry in 1912. During the past week it was a purely national affair, but it was truly national. The exposition and the conventions of the societies emphasized the nation-wide scope of the problems before the chemist at this time. And on the whole it was a glorious week. True, not everything was perfect. There was too much scattering of effort, with meetings going on, often simultaneously, at Columbia University, at the Astor Hotel, at the Chemists' Club, and at the Grand Central Palace. And the very bigness of some of the functions was an obstacle, as in the case of the smoker; in an audience of over 800 men in an immense gilded ballroom the true atmosphere of an old-fashioned smoker cannot develop. But it was a great week, nevertheless, and it proved that the American chemists are fully alive to the tasks set to them, while even the general public is beginning to realize the scope of chemistry as evidenced by the unusual publicity given to the proceedings in the daily papers. We need only remember how the daily press treated the Con-

gress of 1912, in order to realize the progress which has been made in the last few years.

And it was a truly representative and inspiring gathering. The leaders of the profession were there, such as Acheson and Baekeland, to mention just the A and B in the A, B, C of the big leaders of American chemistry. And the rank and file was there. We cannot all be leaders and founders of new industries. But we can all stand together and work together. And the country needs just as much the honest work of the humblest worker of the rank and file as it needs the genius of the leader.

In this respect Chemical Convocation Week will long be remembered as it proved conclusively that the American chemists form, as Dr. Nichols once expressed it, a true democracy. In spite of the scattering of the sessions all over the city, it was a true coming together of American chemists in spirit and resolute desire to help each other. This is the spirit that leads to success. And in the expression of this spirit we see the final meaning of Chemical Convocation Week.

Pittsburgh in Iron and Steel

The annual statistical report of the American Iron and Steel Institute, just issued, gives a little statistical information as to iron and steel production in 1915 not included in the bulletins that have been issued from time to time. Of particular interest is a table of production in Allegheny County, of which Pittsburgh is the center. Unfortunately the production of Allegheny County is not the production of what is strictly entitled to be called the Pittsburgh district, for some fifteen years ago the district outgrew the limitations of the county line. First it extended up the Monongahela River beyond the county line and afterwards it extended down the Ohio River in similar fashion.

Even the statistics of Allegheny County, however, show what a remarkable district is Pittsburgh in the manufacture of iron and steel. Production in 1915 in gross tons was as follows:

Pig iron	5,970,407
Bessemer steel	1,351,416
Open-hearth steel	6,367,036
All other steel	28,928
Total steel ingots and castings.....	7,747,380
Rolled iron and steel.....	5,733,550

Outside the county, but still in the immediate Pittsburgh district, are two blast furnaces at Monessen, two at Donora, four at Woodlawn and one at Midland. As 1915 was not a year of full production, the actual capacity of the Pittsburgh district may be taken as in excess of 8,000,000 tons of pig iron annually.

The great bulk of the pig iron production of Allegheny County is basic iron. It will be observed that the production of Bessemer steel was but 17 per cent of the total steel production, hence the production of Bessemer pig iron was relatively small. There is very little foundry iron produced in the county, there being but one merchant furnace. It is curious that this furnace was the first to be built in the county, except for an unsuccessful furnace in the eighteenth century. Other merchant furnaces were built subsequently, but

have been absorbed by steel interests. A considerable quantity of spiegeleisen and ferromanganese is produced. Even with these complications, however, the consumption of ore and limestone in the manufacture of the pig iron is of considerable interest. All the ore is Lake Superior, of course, and as it is transported a thousand miles from mine to furnace it must be of good quality to make it worth while. With very few exceptions the furnaces are modern and of large capacity. The average consumption per ton of pig iron was as follows, compared with the average of the whole country:

	Allegheny County	United States
Iron ore	1.820	1.843
Mill cinder, scale, etc.....	0.090	0.149
Total	1.920	1.992
Limestone	0.514	0.494

The smaller consumption of iron ore in Allegheny County per ton of pig iron produced is to be expected, as the average of the country at large is pulled up by the relatively low-grade ores consumed in some districts, particularly in the South. The higher limestone consumption would hardly be expected as an attendant phenomenon, and needs to be explained on special grounds.

Allegheny County is practically self-contained as to its steel industry. Very little steel-making iron is shipped into it, but considerable tonnages of old material are shipped into it, and the various shops produce a great deal of industrial scrap, all this material finding its way into the open-hearth furnaces. The production of rolled iron and steel is nevertheless sensibly less than the production of pig iron, despite the fact that a small portion of the rolled material is iron, made directly from scrap, and thus Allegheny County shows, as does the whole country that after all rolled steel is simply produced from pig iron. The scrap produced by the steel works, and charged into the open-hearth furnaces, merely represents a detail in steel production. The statistics of the production of ingots, therefore, are useful chiefly as an index to steel works capacity. The ingot production diverges widely from the quantity of commercial steel produced.

Æsop at the Grand Central Palace

Enjoying a holiday through being on sympathetic strike, Æsop wisely decided to spend it at the National Exposition of Chemical Industries. After gravely and philosophically contemplating innumerable booths decorated with fabrics of many colors or exhibiting vials of priceless crystals and aromatic liquids, he paused in front of an automobile placarded and beribboned like a bridal car, above which hung the legend: "Niagara Made Detroit Possible." He combed his whiskers meditatively with his knotted fingers and was heard to mutter:

"A dog, bearing in his mouth a piece of meat that he had stolen, was crossing a smooth stream by means of a plank. Looking in, he saw what he took to be another dog carrying another piece of meat. Snapping greedily to get this as well, he let go the meat that he had, and lost it in the stream."

The Growing Wealth of the United States

There has hitherto been danger of overestimating the increase in the wealth of the United States arising from the large favorable trade balances, but the successive large increases in the balances in recent months indicate that all overestimates will be made good.

In making computations there has been great liability to err by neglecting certain vital factors. Commonly the assumption has been made that the merchandise balances in the past have sufficed approximately to equalize with the unseen balance against us, and that is greatly to be doubted. Sometimes also there is a disposition to assume that since the war started the unseen balance against us has been smaller than formerly. That also is to be doubted.

It was in 1898 that the first really large favorable balance developed. The average balances in eight-year periods have been as follows:

1898-1905.....	\$509,339,793
1906-1913.....	500,393,290

It seems altogether unreasonable to assume that the majority of items in the unseen and unfavorable balance did not increase during the period covered by the above presentation, and yet the favorable merchandise balance did not increase, but decreased slightly. There was an increase of 64 per cent in our imports, hence freights paid on imports to foreign vessel owners certainly increased, and that is an important item in the unseen balance. Expenditures abroad of American tourists undoubtedly increased. With the large increase in immigration remittances abroad of foreign born residents presumably increased. Foreign holdings of American securities increased, hence the payment of interest and dividends to foreign holders increased. There was no important change in the gold movement.

There is every reason to believe, therefore, that the unseen balance increased, and with no help by an increased merchandise balance the liquidation must have occurred by American securities being sent abroad. We ran into debt faster in the eight years ended 1913 than in the eight years ended 1905.

In 1914 the merchandise trade was very unfavorable, while in 1915 there was a record balance in our favor, the balances being as follows:

1914.....	\$324,348,049
1915.....	1,768,883,677
Total.....	\$2,093,231,726

At the end of 1914 we owed money, which was paid in 1915. If the unseen balance necessary to be liquidated was \$500,000,000 a year we gained in capital in the two years by a trifle more than \$1,000,000,000. In all probability that is an excessive estimate, as the imports were large and freights paid to foreign vessel owners were very high. Our net receipts of gold in the two years were \$585,757,087. Apparently, then, there was little left, up to Jan. 1, 1916, to be liquidated by our making loans abroad or by our buying back our securities.

One will probably be not far wrong in assuming that

our loans to foreign nations and our purchases of our own securities are all to be set against favorable merchandise trade balances that have accrued since the first of this year. The loans total fully \$1,250,000,000, the largest being the \$500,000,000 joint Anglo-French loan of last year and the \$250,000,000 British loan recently, the latter being based upon American securities gathered in London as collateral. We are not altogether clear as to the bearing of the reports made by Mr. L. F. Loree as to the reduction in our railway securities held abroad, and in any event there is nothing definite as to the reduction in securities other than railroad. The total reduction may easily be, to use round figures, \$1,750,000,000, making with the direct loans \$3,000,000,000 altogether. This year's trade balances have been:

January to June	\$1,198,576,369
July	262,749,062
August	310,752,609
Eight months	\$1,772,078,040

The net gold imports in the same time have been in the neighborhood of \$250,000,000, leaving \$1,500,000,000 of the merchandise balance to be settled otherwise, but if we have loaned money and purchased our securities to the extent of \$3,000,000,000 there would appear to be a foreign credit of one-half this amount.

It will be understood, of course, that we do not regard these figures as precisely accurate, and at minor points the reasoning may be subject to some question, but on the whole it seems clearly evident that the foreigners have taken excellent care of their finances and that to square ourselves we must have large favorable merchandise trade balances in the future. The August balance was at the rate of \$3,700,000,000 a year. Roughly speaking, the foreigners have apparently taken care of five months' of trade balances, beginning Sept. 1. It is a matter of common trade knowledge that large payments have been made on munition contracts before the manufacture began, and that payments are made on delivery at seaboard, before the merchandise is actually loaded on vessel.

Assuming a continuance of these trade balances for some time to come, the country will have become rich by the return of a large volume of American securities, and by the loaning of a great deal of money abroad. By reason of these changes the unseen balance against us will be greatly reduced for the future, and we may even be placed in the position England has long enjoyed, whereby revenue from investments flows into the country. If we had an adequate American merchant marine we should earn money by that means also. A condition may be conceived, therefore, of our being able in future to import a larger value of merchandise than we export. If a country can really afford to do this, and the imports and exports respectively are of the right character, the condition is a highly satisfactory one. The prime requisite, in any event, is that the tariff be so regulated that both our import and our export trade is made conducive to the prosperity of the people as manufacturers and traders. There is a grand opportunity to be embraced.

Readers' Views and Comments

Why Boiler Tubes Need Not Be Subject to Coarsening

To the Editor of Metallurgical & Chemical Engineering

SIR:—In an important paper¹ on the coarsening of low-carbon boiler-tube steels, White and Wood infer that these are necessarily in danger of bagging or failure (page 26 of preprint). This they infer from the fact that their results, if extrapolated, indicate that the first stages of coarsening will occur in such steel on exposure for nearly three years to a temperature as low as 400 deg. C., provided that it has first undergone the special form of deformation used in their experiments. This was to indent it with a 5-mm. ball under a load of 800 kg. They truly hold that such tubes may undergo some degree of plastic deformation after annealing and before service, and further that local overheating may be brought about in them in service by the presence of even a thin layer of boiler scale.

Were it true that the tendency to coarsen is as strong after very slight plastic deformation as it is after the severe deformation which these investigators use, their fears would be quite justified. In fact this tendency increases directly with the degree of deformation which the metal has undergone, so that the slighter the deformation has been, the longer is the time and the higher is the temperature needed to cause coarsening. It is this that explains the relative rarity of coarsening on slight heating after deformation. Thus while it is true that boiler tubes may well undergo some deformation between annealing and service, it ought to be possible to restrict that deformation to a degree which is insignificant compared with that which Messrs. White and Wood use, and thus to increase the time and temperature needed to cause coarsening too far beyond that to be expected in good boiler practice, and thus in fine to remove this danger.

The severe deformation which the very ends of the tubes undergo when expanded into place need not be considered here, because these ends are well protected from the heat.

HENRY M. HOWE.

Bedford Hills, N. Y.

Electrolytic Formation of Perchlorate

To the Editor of Metallurgical & Chemical Engineering

SIR:—In the discussion of a recent paper before the American Electrochemical Society on the "Electrolytic Formation of Perchlorate" occur the following passages:

PRESIDENT ADDICKS: The experiments on the oxidizing effect of oxygen activated by ultra-violet light remind me of work I was interested in several years ago in connection with the recovery of selenium from flue dust. The selenium was leached out using $KClO_3$ as an oxidizing agent in shallow porcelain pans in the open air. It was found that the yield was much greater on sunny days than on cloudy ones.

C. W. BENNETT (*Communicated*): We have been unable to bring about the breaking down of potassium chlorate with ultra-violet light. It is probable that the increased efficiency on sunny days is brought about through oxidation of the metal by activated oxygen, the potential of which is sufficiently raised by the presence of the chlorate.

It was a pity to drive Mr. Bennett to looking for an explanation of a phenomenon which was incorrectly re-

¹Recrystallization as a Factor in the Failure of Boiler Tubes, by A. E. White and H. F. Wood, June, 1916, meeting of the American Society for Testing Materials.

ported. The reagent used was a mixture of $KClO_3$ and HCl , the selenium being brought into solution as chloride.

DONALD M. LIDDELL.

7 Wall Street, New York City.

Coming Meetings and Events

American Gas Institute, Chicago, Oct. 17-20.

American Mining Congress, Chicago, Nov. 13-18.

American Society of Mechanical Engineers, New York, Dec. 5-8.

American Institute of Chemical Engineers, New York, Jan. 10-13, 1917.

The Western Metallurgical Field

The Vindicator Flotation Test Plant

Fig. 1 is the flow sheet of the Vindicator Flotation Test Plant, the nature of which is clearly indicated in the drawing. The new features of interest are as follows: The ore is washed before milling and the waste is sorted out; the ball-mills are placed in series instead of in parallel, as is the usual practice; the tailings are tested on a Wilfley table, which acts as a pilot table and indicates the correct working of the process. This table is closely watched, and if any concentrates are observed on it the process is not working at its highest efficiency. The trouble is then looked up and remedied.

Another striking feature is the handling of the tailings. These are pumped over a mountain. The length of the tailing pipe is 8000 ft. and the elevation, including the friction, is 408 ft.

Ball-Mills at the Hollinger Consolidated

The general tendency in the past few years in the Porcupine district has been the replacing of the stamps by ball-mills. The Dome company gradually increased its output by replacing the stamps by ball-mills. Now the Hollinger Consolidated has added a new ball-mill to their plant, enabling them to treat the full estimated tonnage of 1900 tons per day. Improvements have also been made in the cyaniding department which materially increase the efficiency, and the new electric substation which has been under construction is rapidly nearing its completion.

Mills

The general trend of the West is to increase the output of the mills. The Pacific Mine, Utah, is constructing a new mill on Dutchman Flat to handle its sulphide ores. The mainstay of the mine is its copper sulphide, which yields a concentrate running from \$50 to \$60 per ton. Some lead-silver ores are also available. The mill under construction has a daily capacity of 65 tons. As the ratio of concentration is 1 to 4, the daily output of concentrates will be between 15 and 16 tons. The machinery is practically all on the ground and the mill is expected to be in operation by Nov. 1. The mill will be so constructed as to permit the addition of new units as the output increases.

Within a short time the Big Four Exploration Co.'s mill situated at Park City, Utah, will increase its output from 400 tons daily to 1000 tons of tailings. This is accomplished by modifying the feeder system. In approximately a month's time the new flotation plant

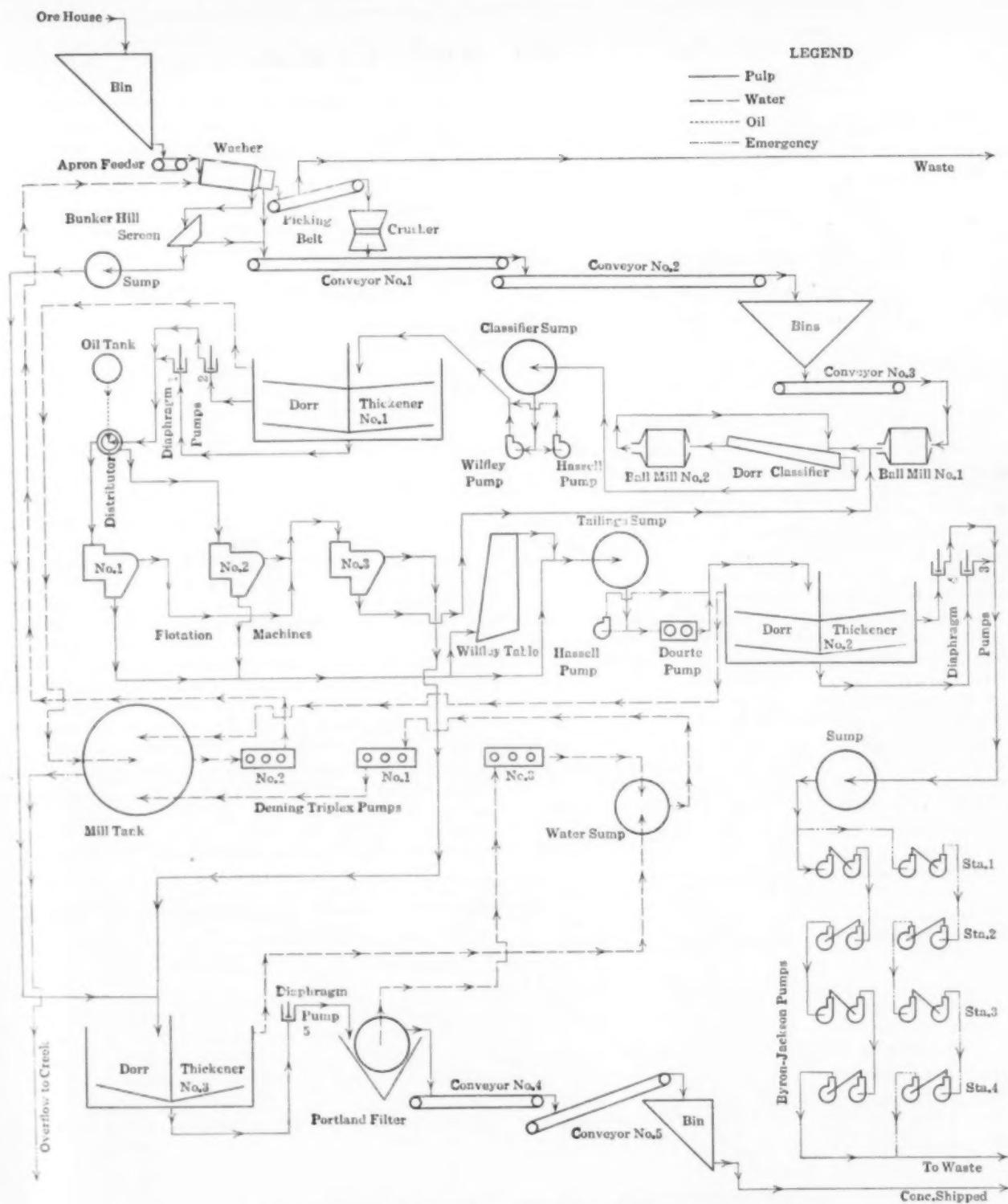


FIG. 1—FLOW SHEET OF THE VINDICATOR FLOTATION TEST PLANT

will also be in operation, which will materially increase the savings on the slimes material. When working at full capacity the mill will turn out 1500 tons of lead-iron concentrates and zinc concentrates per month.

Relief of the Smelter Congestion

For the past few months the smelters of the Salt Lake valley have been congested with ore, due to the unusual activity in mining brought about by the high price of silver, lead and copper. It was impossible for the smelters to handle all the ore shipped them, and material has been refused which at other times

was gladly accepted. The American Smelting & Refining Co. has solved the problem by increasing the capacity of its Garfield and its Murray plants.

The plant at Garfield will be enlarged in such a manner as to double its capacity within the next half-year. The smelter will then be able to turn out 800 tons of copper a day, which is equivalent to 48,000,000 lb. per month. The plans have been completed and some of the structural steel is already on hand.

The demand for an increased capacity of the Murray plant was even more stringent than for the Garfield plant. This was due to the insistent demands of the small producers, scattered all through the valley,

that their ore be taken care of. The Murray plant handles lead-silver ores, and steps have been taken to increase the capacity of the plant to such an extent as to handle all the ore shipped in. The furnaces will be enlarged and improved and a new stack 450 ft. high will be built. This stack will be the second largest in the world. The Murray plant, it is expected, will be operated on its new basis within six months.

A New Sampler at Salt Lake City

Due to the large output of ore it was found necessary to consider the erection of a new sampler at Salt Lake City. This sampler is expected to handle ores from Utah and the surrounding States. The new sampler will have an initial capacity of 750 tons per day, and will be so constructed that additional units may be added when found necessary. It will be of the Vezin type, and will cost \$75,000. Construction will be started as soon as the final details are worked out.

Cupellation Losses in Assaying

A study of the losses in cupellation assays has been published in the 1916 Bulletin of the School of Mines and Metallurgy, University of Missouri, by Profs. HORACE THARP MANN and CHARLES YANCEY CLAYTON. The topics considered are: Method of operation, screen analysis of bone-ash, losses due to composition of cupels, effect of moisture and hardness, effect of surface condition of cupel, and slag losses.

The Mode of procedure was as follows: The silver-foil used in these tests was carefully weighed and wrapped in lead-foil weighed to the nearest half-gram. When impurities were used, such as copper, tin and zinc, they were weighed accurately and added to the silver-foil and lead-foil button. Frequent analysis for gold and silver were made on all materials. Gasoline-fired muffles were used. Each run consisted of five rows of six cupels each across the muffle. The first row was placed about 3 in. back from the mouth of the muffle and acted as a guard to protect the experiments from any chilling effects. They contained

no buttons. Before placing the buttons in the cupels the latter were heated to 925 deg. C. to 950 deg. C. On placing the buttons in the cupels the muffled doors were shut until the buttons were well opened, and then removed and the temperature of the muffles maintained as constant as possible at that temperature where litharge feathers formed around the button. This temperature was maintained until 1 min. before the "blick," when the coolers were taken out and the temperature of the furnace raised. The cupellation was finished between 850 deg. C. to 900 deg. C. Platinum-platinum rhodium couples were used to measure the temperatures.

Screen Analysis.—The bone-ash used for all laboratory cupels gave the following screen analysis:

On	Screen	Size Opening, Inches	Per Cent
	28 mesh	0.0232	0.00
	35 mesh	0.0164	0.10
	48 mesh	0.0116	5.30
	65 mesh	0.0082	14.20
	100 mesh	0.0058	22.50
	150 mesh	0.0041	9.30
	200 mesh	0.0029	16.20
	220 mesh	.....	0.20
	240 mesh	.....	5.20
	260 mesh	.....	5.30
Thru	260 mesh	.....	21.70
			100.00

Losses in Cupellation When Using Different Materials for Cupels.—Nine different cupels were used in these tests—bone-ash, a mixture of one-half bone-ash and one-half cement, cement base with a bone-ash top, cement, Morganite, Braunit, patented cupel No. 1, patented cupel No. 2 and patented cupel No. 3. Each cupel was charged with 20 grams of lead-foil and 20 mgs. of silver-foil. The results obtained are clearly indicated in Fig. 2, the best results being obtained by the Morganite and the Braunit cupels.

Effect of Moisture and Hardness of Cupels on Silver Losses.—Five sets of cupels were made with varying degrees of moisture (5, 8, 12, 17 and 22 per cent). From each one of the above, cupels of various hardness were made. All of these cupels were then used

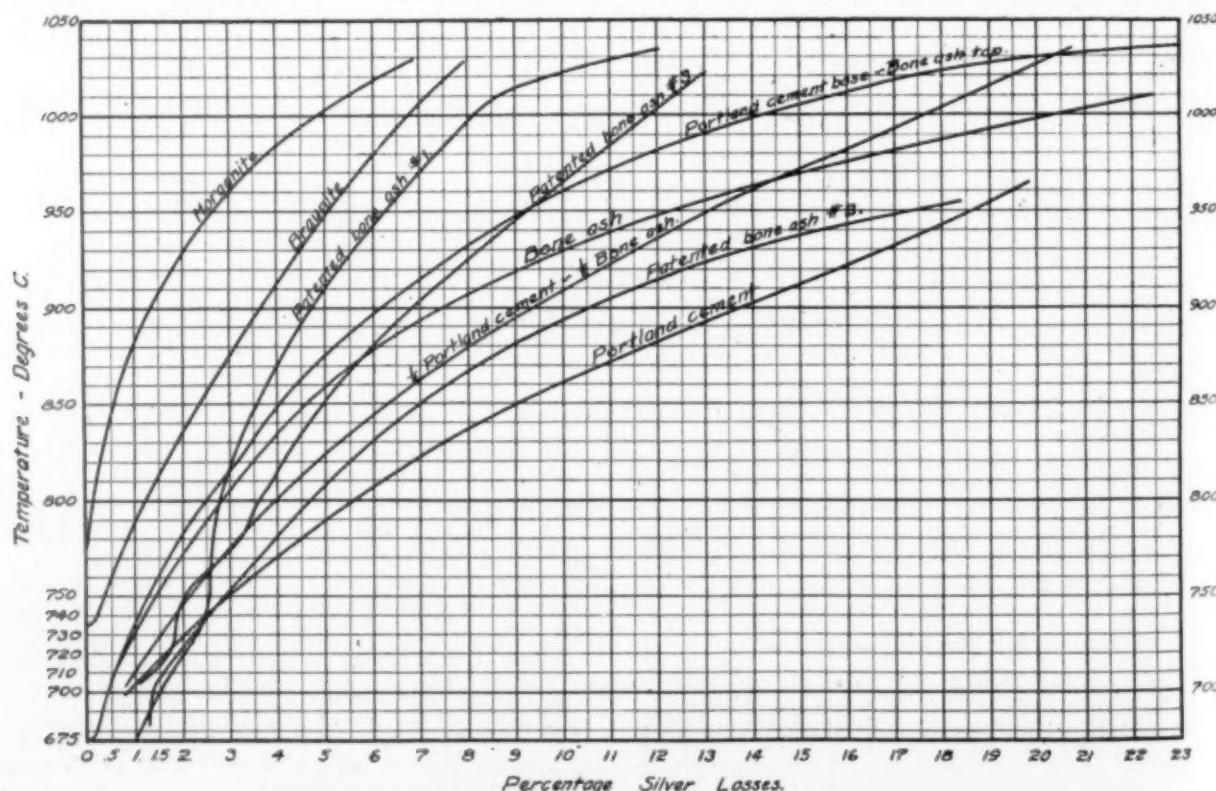


FIG. 2—CUPELLATION LOSSES USING DIFFERENT MATERIALS FOR CUPELS

in the described manner, and the results obtained show that moisture and hardness have very little effect on the silver losses. The only effect worthy of notice is that the very soft cupels finish slightly ahead of the harder ones.

Effect of the Surface Condition.—The surfaces of the cupels were made more or less smooth by rotating them in the cupel molds. To obtain a rough surface the cupel, after removal from the mold, was scratched until all of the smoothness had been obliterated. The conclusions drawn from these experiments were that the surface condition of the cupel had practically no effect on the silver losses.

Effect of Size of Bone-ash on Cupellation Losses.—Sized bone-ash was used, the mesh used being 40, 60, 80, 100, 120, 150 and 200. From the results obtained it was found that providing the bone-ash passes 60 mesh, the size of the particles has practically no effect on the silver losses. It was also observed that all cupellations require the same length of time for completion.

Assay Slags and Silver Losses.—The authors, believing that the chemical composition of the slag effected the losses only to a very slight degree and ascribing the silver losses mainly to physical causes, such as imperfect decomposition, spitting, suspension of lead particles in slag and to volatilization, performed a series of experiments showing that under ordinary working conditions this holds true. The only conditions stipulated are those of good fusion. These are: Complete decomposition of the ore, formation of a fluid slag, furnishing the proper amount of collector at the proper time and keeping out of the lead button any impurities which might cause a subsequent loss. The mode of procedure was to make a number of fusions so as to give 50 grams of slag of a definite silicate degree, using standard reagents and keeping all conditions as constant as possible. A second set of experiments performed on silver ores under the same conditions as above, with the exception that the amount of slag formed varied, gave the same results.

The Joint Convention of the American Foundrymen's Association and the American Institute of Metals

A very enthusiastic gathering of iron and brass foundrymen and others interested in this particular branch of metallurgy occurred in Cleveland during the week of Sept. 11. The occasion was the technical sessions comprising the annual meeting of the American Foundrymen's Association, the American Institute of Metals, and the no less important exhibition of foundry equipment, appliances and materials held simultaneously at the Coliseum.

The technical sessions were inaugurated by a joint meeting on Tuesday, when subjects common to both societies were presented. On following days the two associations not only met separately, but on two mornings the foundrymen divided themselves into halves; on one occasion one section discussing electric steel while the other portion was considering malleable iron; and on another a session on gray iron and the other on steel castings were in progress. This made it difficult at times for the visitor of more or less diverse interests to make up his mind in which of the sessions he was most interested, then attend it, and submerge his regret that he could not be in three rooms simultaneously.

The program committee had arranged to devote only the mornings to the consideration of papers, hoping in that manner to secure a large attendance at the formal meetings, practically unaffected by the attraction of

such features as plant visitation, the exhibition at the Coliseum and the various social events. In this they were apparently successful, but one who had recently attended the strenuous Electrochemical Society meetings could not but wish that more of the day could have been devoted to the most interesting technical sessions. It was also to be regretted that some of the absent authors could not have been represented on the floor by a fellow member who could read at least an abstract of the paper. Lacking this opportunity, an important paper like that of A. F. Taggart on "The Reclamation of Brass Ashes" was passed with the formality of reading by title. However, the discussion of papers at the sessions of the Institute of Metals was especially noteworthy. When a paper had been presented, the discussion was usually spontaneous, sparkling and clarifying; in case the interest seemed to flag the chairman would call upon members who had not yet given their experience with the matters under debate to arise and unburden themselves for their own relief and their associates' profit.

As is perhaps well known, the American Institute of Metals is an off-shoot from the American Foundrymen's Association, organized some few years ago by those interested in the metallurgy of the nonferrous metals. That the child bids fair to outstrip the parent is evident from the membership—which in the case of the Institute of Metals has steadily grown up to half the size of the older organization, which on the other hand, is now nearly stationary in numbers—and from the fact that the daily attendance of the younger body was equal to at least 25 per cent of its enrolled membership, a point which the Institute members view with considerable pride.

Tentative moves toward reconsolidation were viewed with marked disfavor by the members of the Institute.

Their sentiments were perhaps best expressed by Vice-President Wallace, who declared that the Institute was eminently well fulfilling the purposes in view on its organization—that it had proved to be an invaluable meeting ground for men interested in all phases of the complicated metallurgy of alloys; a meeting ground where the engineer and scientist meet the metal founder, the latter sharpening his wits and learning the true reasons for certain reactions, and the former becoming acquainted with the needs and difficulties of the practical melter.

In this very manner the Institute itself seems, in the opinion of the writer, to be the most potent instrument leading to closer co-operation between the engineer and the foundry—a subject, by the way, treated with less virility previously during the opening joint session in a symposium by D. W. Sowers, J. H. Hall and G. F. Meehan from the founders' and C. E. Chase from the engineers' standpoint. As developed by this discussion, the foundrymen's chief objection to the engineer seems to be that he pays too little attention to the design of his castings so that they can be economically molded and cast without danger of shrinkage, cracks and spongy spots. The engineer, on the other hand, objects to the acceptance of castings made from peculiar foundry mixtures of "secret composition" and undetermined physical characteristics. It would seem that the precise knowledge available is such an infinitesimally small proportion of the whole field of alloys that engineers, in their ignorance, are constantly combining a chemical specification with impossible physical properties, and demanding a casting to suit. Dr. Moldenke closed the discussion with pointed remarks to the effect that co-operation between engineer and foundry was no longer desirable but absolutely necessary, and he advised foundrymen to make their sons first into engineers, and then into foundrymen.

The oration of the meeting was delivered, not at the banquet nor at the opening session, but at that same morning meeting when Mr. R. R. Clarke of the Pennsylvania System addressed the joint session, elaborating upon his most excellent paper—"Gating Non-Ferrous Metal Castings"—and wildly riding his hobby on "When is a Gate, and Why?" through the vanquished ranks of his opponents, to the huge delight of the innocent by-standers. Mr. Clarke not only knew what he was talking about, but he had excellent examples of his casting practice to exhibit to any doubting Thomas.

Following a strong appeal for fire prevention delivered by F. H. Wentworth, secretary of the National Fire Protection Association, both societies authorized committees to co-operate with that body. In the discussion a little appreciated fact was brought forth from the floor that in a recent design of a foundry addition, comparative estimates showed that an absolutely fire-proof steel and wire glass construction could be erected for about 75 per cent of the cost of a wooden "fire trap."

On Wednesday morning a long and most interesting paper by Charles Pack on the "Evolution of the Die Casting Process" was read. Mr. Pack has collected together an immense amount of archeological and historical lore regarding foundry practice from ancient times forward. He showed how metal founding had almost become a lost art during the dark ages, and even now had hardly recovered the high plane of the ancient handicraft. Mr. Pack thinks the modern die casting to be a direct descendant of the type founders' product, and the Mergenthaler linotype a notable example of the modern die casting machine.

When showing lantern slides of a wood cut illustrating a foundry of a century ago, some members exclaimed that it looked exactly like the modern foundry. Unfortunately it is too true. The exposition of foundry appliances, while notable and the recipient of many congratulations, exhibits only too clearly the necessity of another "Duquesne Revolution" which must strike the metal foundry to lift it out of the dirty, smoky, sweaty and superstitious condition it has inherited from the centuries.

Perhaps the most interesting paper presented on Thursday, Sept. 14, was by Mr. S. W. Miller, on the "Application of the Oxy-Acetylene Welding Process in the Repair of Defective Non-Ferrous Castings." He described an extensive series of experiments which he had conducted in developing an alloy which could be used under the blow-pipe for filling in cavities in brass castings. He pointed out that a *perfect* weld was impossible to make by any known process in a tin alloy, because under even gentle heating the very fusible tin eutectics would liquefy at the joint, thus leaving a spongy muff about the welded insert.

Dr. P. D. Merica of the Bureau of Standards also emphasized the variation in chemical composition, physical constitution and internal strains existing at a welded or "burned-in" area in metallic substances in his paper on "The Initial Stress Produced by the Burning-In of Manganese Bronze." Too little consideration is given these non-homogeneous portions, sometimes with disastrous results; notably in the case of the failure of the large bronze valves at the Catskill Aqueduct.

On the final day of the Institute of Metals, Mr. P. E. McKinney, U. S. N., gave an interesting paper on the results he had been securing in the making of sound aluminium castings and forgings at the Washington Navy Yard. In this work he discovered that even the smallest amounts of iron, carbon or silicon entering into the aluminium alloy would weaken the metal and increase its brittleness. For this reason he recommends melting in a graphite crucible, clay-lined; stirring with

clay-lined tools; and avoiding heating the metal much above the melting point. Hot aluminium is very corrosive, and the best castings can be poured from metal under the dullest red.

"Seasoning Cracks and the Self-Annealing of Brass" was discussed at length by W. Arthur, Frankford Arsenal, and other engineers interested in the manufacture of munitions, more especially of cartridge cases. They seemed agreed that the cracks occurred in places where an excessive gagging of the metal had occurred during pressing. The proper steps for prevention, therefore, were evidently those leading to a more careful design of the dies used in forming the objects. Such seasoning cracks are particularly troublesome because they appear in a piece only after a decade's storage. Why it takes so many years for the crack to appear in an apparently sound piece of metal still remains an unsolved problem. It possibly may be due to the slow conversion of a metastable amorphous state caused by drastic cold working. At least it was agreed by those present that it could not be attributed to the excrement of the rodent inhabitants of the arsenals—an explanation advanced by one of the manufacturing firms and forwarded to the War Department. Co-operation between engineer and foundry has eliminated such ideas as these, at least. We have hopes it will go even further.

E. E. THUM.

Arizona Meeting of American Institute of Mining Engineers

The 113th meeting of the American Institute of Mining Engineers, which was held in Arizona from Sept. 18 to 23, turned out, as expected, a big success in attendance as well as in interesting features. This was the first time the Institute held a meeting in Arizona and the gathering was most enthusiastic. The prominence of Arizona as a copper producer (being now the leading district) and the large number of new smelters and mills erected there during the last few years made it an ideal place for a meeting. The meeting was in the form of a tour of the mining and metallurgical districts of the State with technical meetings held at various localities.

The Eastern party left New York, Boston and other Eastern cities on Thursday and Friday, Sept. 14 and 15, arriving at Chicago Friday evening in time for a ride around Chicago in autos and dinner at the Hotel LaSalle. They left Chicago late Friday evening, arriving at El Paso, Tex., Sunday afternoon, where they were enthusiastically welcomed by the Arizona members. A visit was then made to the smelting works in the vicinity, and to various points of interest around the city. An interesting feature in the evening was a Mexican dinner at the Toltec Club.

The party left El Paso late Sunday night arriving at Santa Rita, N. M., early the next morning. Here a very interesting and enjoyable inspection trip was made to the Chino Mines and Empire Zinc Co.'s works. At noon the party was treated to a barbecue, with the U. S. Military Band from Fort Bayard furnishing lively music. In the afternoon the party went to Hurley in automobiles and inspected the Chino mill where interesting developments in flotation work are under way. In the evening a dance was held in a temporary pavilion which was greatly enjoyed.

Leaving Hurley that evening the party arrived at Douglas, Ariz., the next morning, and the members were taken in autos to the Copper Queen Consolidated smelter, and the Calumet & Arizona Mining Co. A lunch was served at the Calumet plant.

In the afternoon a technical session on "smelting"

was held at which WALTER DOUGLAS presided. A paper was presented by A. G. McGREGOR on "Features of the New Copper Smelting Plants in Arizona." (This was published in full in our Sept. 15 issue.) The paper was discussed by Sidney Jennings and E. P. Mathewson. An interesting paper on "Smelting at the Arizona Copper Co.'s Works" was then read by F. N. FLYNN. L. O. HOWARD's paper on "The Basic Lined Converter in the Southwest" followed. This was discussed by Messrs. Douglas and Mathewson and some interesting comparisons of the cost of Anaconda and El Paso converters and of the lining qualities was brought out. A paper by J. MOORE SAMUEL on "Determination of Dust Losses at the Copper Queen Reduction Works" brought out considerable discussion. E. P. Mathewson thought it advisable to collect the flotation concentrate dust in collectors and to build roasters to prevent dust as much as possible. Sidney Jennings advocated the use of a bag house. A. G. McGregor also participated in the discussion.

At the Tuesday evening session on "Leaching" WALTER DOUGLAS presided. H. W. MORSE and H. A. TOBLEMAN presented a paper on "Leaching Tests at New Cornelia." In a communicated discussion of this paper Lawrence Addicks said that graphite may succeed as anode material in the copper sulphate electrolyte, but that further experimentation was needed. Geo. D. Van Arsdale compared the advantages and disadvantages of lead and graphite electrodes. Messrs. Schimerks, Grabill, and Flynn also discussed this paper.

FREDERICK LAIST and HAROLD ALDRICH were the joint authors of a paper on "A 2000-ton Leaching Plant at Anaconda." Messrs. Flynn and Mathewson discussed the paper. LAWRENCE ADDICKS' paper on "Possibilities in the Wet Treatment of Copper Concentrates" was then presented. F. N. Flynn in discussing this paper advocated leaching flotation concentrates direct without roasting. A general discussion on leaching then took place, at which F. S. Schimerks described leaching at Clifton. H. E. Williams described the Calumet & Hecla ammonia process on tail dumps. Messrs. Mathewson and Van Arsdale spoke on wooden versus concrete tanks. Mr. Mathewson said wooden tanks were more economical for a small plant.

The party left Douglas late Tuesday evening arriving at Bisbee in about two hours. On Wednesday morning the mines in this district were visited and after luncheon a technical session was held on "Mining and Geology" at which GERALD SHERMAN presided.

The party left Bisbee late Wednesday evening, arriving at Globe Thursday morning. At Globe the mines and reduction works of the old Dominion Copper Co. were visited and after luncheon a technical session was held on the general subject of "Concentration and Flotation." A paper by DAVID COLE on the "Advent of Flotation in the Clifton-Morenci District, Arizona, 1914-1915," was presented. This was followed by the "History of the Flotation Process at Inspiration" by RUDOLF GAHL. (The first part of this paper is printed in full elsewhere in this issue.) In a communicated discussion of this paper Frederick Laist said that the pneumatic machine was better for alkali solutions and the non-pneumatic better for acid solutions. He also said that power was the main factor in the choice of a machine. Mr. Cole thought that elimination of classifiers was possible. E. P. Mathewson discussed practice at Montana and L. D. Ricketts thought that gravity concentration followed by flotation was best. The paper was also discussed by Messrs. Schimerks, Morse, Handy, Chase, Cottrell and Ruggles.

A paper on "Some Miscellaneous Wood Oils for Flota-

tion" was presented by R. C. PALMER, GLENN L. ALLEN, and O. C. RALSTON. "Flotation Concentration at Anaconda" was described in a paper by FREDERICK LAIST and ALBERT E. WIGGIN. In the discussion Rudolf Gahl said that wood oils retain part of the gangue, and asked why acid was added in one locality and not in another. Messrs. Ralston, Cole Watt, Gottsberger, Merrill, and Schimerks also participated in the discussion.

At the Thursday evening session several papers on mining were presented. P. G. BECKET acted as chairman.

On Friday morning a very interesting visit was paid to the reduction works of the International Smelting & Refining Co. and the mills of the Inspiration Consolidated Copper Co. and the Miami Copper Co.

On Friday afternoon a technical session was held on "Mining and Smelting," at which B. B. GOTTSBERGER presided. CHARLES LE GRAND presented a paper on "The Power Plant of the Burro Mountain Copper Co." The paper was discussed by Messrs. Gottsberger and Kidder. A paper on "Comparative Tests of the Marathon, Chilian and Hardinge Mills" was presented by F. C. BLICKENSDERFER. In discussing the paper Mr. Gottsberger compared the Miami and Inspiration plants, and compared pebble mills with ball mills. Mr. Schimerks said there was linear action instead of spherical action in the Marathon mill. Messrs. Watts, Kiliani, Franke, and Merrill also participated in the discussion.

A fuller report, with notes on the concluding days of the meeting, is reserved for our next issue.

The Iron and Steel Market

The second half of September has proved in distinct contrast to the first half, for while the iron and steel market generally was rather quiet despite its distinct underlying strength it has since become decidedly active. What amounts to a real buying movement in steel products is now in progress, while the pig iron market has increased farther in activity, the demand resulting in an excited market with prices sharply advancing.

In the ranks of buyers generally there has been an accretion of confidence as to business conditions next year, whereby there is a general desire to cover. Three months ago jobbers and manufacturing consumers were alike doubtful as to the future, and were disposed to purchase only such material as it was absolutely certain they would require. First the manufacturing consumers began to conclude that the market would be strong and commenced buying on a more liberal scale. The jobbers were more reserved and it is only in the past fortnight that jobbers as a class are showing real confidence as to market conditions in the fore part of next year.

Apart from the steel buying that results from the buyers having greater confidence in the future there is an increase in the actual consuming demand. The railroads have entered the market again, after a long abstinence from anything like liberal buying, and have bought a moderate number of freight cars, while there is now inquiry for fully 20,000 cars, despite knowledge on the part of the roads that very high prices will have to be paid, approximately double the lowest prices of the past. There is considerably more structural work coming to a head, investors showing a tendency to abandon the policy of waiting for the lower prices expected to obtain after the war. Contracting for ships continues heavy, even though the best deliveries obtainable now are in 1918. The Sinclair Oil Company is in the market for 800 miles of 6- and 8-in. pipe for oil lines to its projected refineries at St. Louis and Chicago, the lines involving about 60,000 tons of steel

plates. The automobile trade is urging the sheet manufacturers to accept contracts for the first half of next year, and price seems to be secondary to assurance of delivery.

There is a marked advancing tendency in steel prices. Bars, plates, shapes, sheets and wire products are all predicted to advance within the next fortnight, and it certainly appears that there has commenced another distinct buying movement in the steel industry, with the customary advances in prices.

Conditions Without Precedent

This is a period of unprecedented conditions, and this steel movement is entirely lacking in precedents, in that it follows, without an intermediate break, the previous movement. Never before in the history of the steel market has such a thing occurred. There have been buying movements of greater or less duration, and with larger or smaller total advances in prices, but in all the past each movement has been distinct, and periods of heavy recessions have intervened between the movements. The regular course is for buying to be heavy for a period, with prices steadily advancing, this being followed by a period of light buying and stationary prices, winding up with a market break and falling prices, with buyers holding off and waiting until prices approximated the cost of production before taking hold again.

The recent buying movement was on a modest scale during the first half of 1915, increasing in intensity in the late months of the year and extending through the first three months of this year. During the first nine months of 1915 price advances were moderate, averaging about \$5 a net ton on all important steel products outside of rails. In the next six months, through March of this year, the advances averaged \$20, or four times as much in two-thirds the time. In the four months April to July inclusive advances were merely sporadic, averaging only about \$2 a ton on all products. Following a period of such rapid advances and excited buying that period must be regarded as a dull one, with prices relatively stationary. At the beginning of August prices began to show a fresh advancing tendency, though only a slight one, but buying remained on a conservative scale. Now prices show a rather sharply advancing tendency and the buying is much freer. It appears to be a distinctly fresh movement, and in some quarters really famine prices are expected to prevail before the end of the year.

There is absolutely no sign thus far of high prices for steel cutting down consumption to such an extent as to increase the offerings. Steel is scarcer than it has been at any previous time in this general movement. Unfinished steel is practically unobtainable at any price, while in finished steel products the mills in the different departments are sold up practically as far as they are willing to sell.

Pig Iron Sharply Advancing

The buying of pig iron which began on a fair scale early in August developed into an excited movement in the last ten days of September, with considerable excitement and with prices advancing sharply. During the first half of the year pig iron had been practically stationary, following its moderate advance in the late months of 1915, and throughout the half year there were predictions that pig iron would eventually experience a sharp advance, the theory being that a scarcity would develop because steel making capacity was increasing while pig iron production could not be increased, and the full necessary supply had previously been eked out by drawing upon stocks. Not a single sign of scarcity appeared in July and August, perhaps because the hot weather in those months curtailed steel production

more than pig iron production. When the regular buying movement opened early in August the furnaces were ready to sell for the first half of 1917 at prices then prevailing for earlier deliveries and their readiness to do this was far from suggestive that they themselves expected a scarcity. The selling represented the familiar accumulation of "back log tonnage," a practice not conducive to a stiffening in prices. If the furnace interests had had a moderate degree of courage, a moiety of that shown right along by the sellers of steel, they could have secured much higher prices for their iron as the buyers needed iron and were in no position, with their large profits, to quibble over pig iron prices. Eventually, however, the furnaces got through building up the backlog, and as soon as they showed any reserve about selling, the market started to advance sharply. In a few days Bessemer pig iron at valley furnaces jumped from \$21 to \$22.50, with large sales at intermediate prices and at the top, while at this writing the material appears to be very scarce and may advance farther. Basic pig iron similarly jumped from \$18 to \$19, valley. Foundry iron, which had advanced slowly from \$18.25 to \$18.50 moved up to \$19 in sympathy with basic. Other pig iron producing districts showed a stiffening tendency but did not advance sharply, as they were not under the control of steel making iron as is the case with the valley-Pittsburgh district.

Unfinished Steel

The fourth quarter price on Carnegie sheet bar contracts is understood to have been fixed at \$42, but there are slight concessions from the regular price in the case of most of the mills. The advance over third quarter amounts quite uniformly to about \$5 a ton, and a further advance for the first quarter is to be expected. There is practically no market for billets and sheet bars as there are no offerings to speak of and the average consumer could not afford to pay prices that would be asked, \$45 to \$50. Consumers are simply operating upon such unfinished steel as is coming to them by reason of old contracts. There is a large export demand, which cannot be satisfied. There has been increased export buying of billet discards produced in making shell steel, not because this particular material is desired but because nothing else can be had.

The nineteenth annual session of the **American Mining Congress** will be held at Hotel La Salle, Chicago, during the week of Nov. 13. The seventeenth floor of the hotel has been engaged for exhibits and considerable space has already been taken. Mr. James F. Callbreath is secretary of the Congress, and his headquarters are Rooms 213 and 214, Hotel La Salle, Chicago.

Trade and Tariffs in South America.—The Federal Trade Commission has issued a report on trade and tariffs in Brazil, Uruguay, Argentina, Chile, Bolivia and Peru. The report is the results of a study made by the Federal Trade Commission of conditions in the above named countries and its scope may be understood by the following quotation from the letter of submittal to Congress. "Realizing how vitally tariff laws and regulations affect the movements of commerce and believing that a study of them would be useful to both the Governments and the business interests of all the American Republics, the Federal Trade Commission has sought to point out in the trade conditions and in the customs laws and practices of Latin America the obstacles encountered, and at the same time to indicate to American business men and to the Governments of both North and South America how these obstacles may be wholly or partly removed."

New York Meeting of American Chemical Society

Opening Session

The American Chemical Society opened its fifty-third annual convention on Tuesday, Sept. 26, with a general meeting in the auditorium of Horace Mann School, Columbia University. The chairman of the New York Section, Dr. J. MERRITT MATHEWS, presided.

The first speaker was Dr. HADEN EMERSON, Health Commissioner of New York City, who urged chemists to devote part of their time to the education of the workmen in the plant. He outlined the work of the Health Department of New York City in the prevention of occupational diseases. He said it was creditable that a session was to be devoted to this subject during the convention and that a permanent section of the American Chemical Society should be formed for the supervision of the working conditions in factories.

Dr. NICHOLAS MURRAY BUTLER, president of Columbia University, welcomed the society to Columbia and expressed the wish that all feel at liberty to inspect the University and make use of its facilities. He paid a splendid tribute to the work of Dr. Emerson, and said that from observations made on a western trip which he had just finished, he found that the scientific problem and the human problem everywhere tend to coalesce. It may be health, ease of operation or other consideration, but the human problem always comes in, as does also the scientific problem. President Butler said that the gathering this week was a mobilization of forces of the country, a large part of civilization's fighting army.

Dr. CHARLES H. HERTY, president of the Society, extended the thanks of the society to the New York section and to Columbia University for the arrangements of the meeting and the privileges extended.

He then called upon Dr. DAVID T. DAY, who outlined the plans of the Joseph A. Holmes Memorial Association for furthering the workmen's welfare and safety work started by the late Dr. Holmes when director of the Bureau of Mines. Dr. Day urged all to give the matter their moral and financial support so that something definite might be accomplished in the form of a nation-wide movement.

Secretary CHARLES A. PARSONS then read a letter from the American Association for the Advancement of Science, advocating a general meeting every four years of all scientific societies in some large city, in the interests of science in general. Dr. Parsons explained that the American Chemical Society had agreed to meet with the Association in December, but changed this decision on account of the Chemical Exposition.

A resolution was introduced and passed that the society endeavor to meet with the American Association in December.

COLLOID CHEMISTRY

Following the business session, two papers were presented. Dr. WILDER D. BANCROFT read a very interesting paper on "Colloid Chemistry" in true Bancroft style. He defined colloid chemistry as the chemistry which has to do with substances which are in a state of very fine division. He gave a long and imposing list of industries in which it plays an important part. A few of them are: Cement, brick, asphalt, pottery, varnish, soap, rubber, milk, butter, purification of water, sewage, photography, but there were many more. He said that our knowledge of colloid chemistry was getting on a firmer working basis, and gave an outline of the present state of the theory from the viewpoint of adsorption.

All liquids and solids adsorb gases. As examples we have the case of broken china. The formation of an air film prevents its sticking together again. It is difficult to make two soap bubbles coalesce due to the formation of an air film. Certain colloidal substances will coalesce immediately after being broken, but if they are left to stand awhile, they will not. It takes time to adsorb the air film.

Solids also adsorb liquids, a phenomenon of which there are many common examples such as the adsorption of water by various solids, with which every chemist is familiar.

Solids also adsorb solids, for example, in polishing with rouges, the rouge sticks to the polished surface unless it is kept moist. Passive iron is due to an adsorbed film of iron oxide. Dyeing is another example. The fiber of the fabric adsorbs a film of the dyestuff.

Adsorption is always selective, i.e., the same substance will adsorb different amounts of different substances. As a first generalization it may be stated that a multivalent ion will be adsorbed more readily than one of lower valency. Solubility is a case of specific adsorption.

If a substance which ordinarily sinks in a liquid is ground fine enough it will remain suspended on account of the bombardment of the particles by the molecules of the liquid. This is the so-called Brownian movement, and is visible by the ultra-microscope.

Colloidal solutions can be made by precipitation, but it must be done in the presence of a substance which is strongly adsorbed. A substance in suspension exerts no osmotic pressure except in so far as there is a solution, consequently the boiling-point method of determining molecular weights is not accurate, as it is not the amount of substance which is added to a liquid which counts in this case, but the amount which goes in solution.

If the protective film which covers the particle be removed by a chemical reagent which dissolves it or precipitates it, then the particles will fall. They coagulate. An electric current will sometimes maintain finely divided particles in a colloidal state by giving each a negative charge so that they repel rather than attract one another. On the other hand, alternating currents of high frequency such as used in the Cottrell process will often cause them to coalesce and thus fall down upon the baffle plates set to catch them. By this means the particles are removed from smoke and fumes.

BY-PRODUCT COKE OVENS

Mr. HORACE C. PORTER read a paper on "Coal and Coke By-Products As a Source of Fixed Nitrogen." He showed that there was sufficient nitrogen available from by-product coke ovens for all our war needs.

The annual capacity for ammonia at coke plants is 113,760 tons of NH₃. At gas works the capacity is 12,500 tons, making a total of 126,260 tons. The practical yield of 95 per cent nitric acid from this ammonia would be 404,000 tons. Our war needs are estimated at 180,000 tons of nitric acid. Mr. Porter thought the proposed Government nitrate plant would hurt the private producers of nitrogen compounds.

Tuesday Afternoon Session

At the public meeting Tuesday afternoon in the Horace Mann Auditorium Mr. JOHN E. GARDIN, vice-president of the National City Bank, New York City, was the first speaker. He said the great fear was that our attempts to build up large chemical industries would be only sporadic, and that Europe would take the fore again when peace was declared. He said we must

create stability in our production. American banks do not have free power to help the industries as the European banks do, on account of banking laws, but capital is available whenever a reasonably satisfactory proposition is forthcoming.

General WILLIAM CROZIER, chief of ordnance of the War Department, said that chemists were needed to help the government with the nitrate plant. The chemists' services are indispensable to the government.

Dr. CHARLES H. HERTY, in his presidential address, laid great stress on the need of co-ordination of effort in establishing our industries. The universities should increase their budgets to their chemical departments so that the increasing demand for men and research work may be met. More graduate fellowships are needed. We must have more detailed information on importations. Our government statistics are now inadequate. Dr. Herty said that provision should be made by the government for storing large quantities of toluol, which will be available from our overproduction after the war. He urged greater investigation of alcohol as a motor fuel. He reviewed the great fight for a dyestuffs tariff extending over the last two years and culminating in a bill which was not satisfactory. He said the American public will not stand for such legislation. Chemistry is occupying a more prominent place in the national thought, as evidenced by the increasing reports in the public press.

Division of Industrial Chemists and Chemical Engineers

The Industrial Division held a meeting in Schermerhorn Hall, Columbia University, on Wednesday, Sept. 27, at which several interesting papers were presented, which elicited considerable discussion.

The "Brewing Industry" was discussed in a paper by CARL A. NOWAK. He said that the brewing industry was entitled to recognition, as it was a scientific industry on a firm basis, and needed the help and recognition of the universities and scientific men in advancing the methods of manufacture.

J. W. TURRENTINE presented a paper on the "Present Status of the Potash-from Kelp Industry of the Pacific Coast."

The "Preparation of Oxalic Acid and Citric Acid by Fermentation" was described by JAMES N. CURRIE.

The "Manufacture of Benzaldehyde and Benzoic Acid" by a new process was described by H. D. GIBBS. The work has been more or less of an experimental nature, but a large-size apparatus is at present being constructed by Mr. Gibbs, and the process seems to offer possibilities. It consists in subjecting toluene and chlorine in the gaseous state at 110 deg. C. to the action of ultraviolet light and other catalysts with the formation of benzal chloride and benzal trichloride. This is converted by hydrolysis into benzaldehyde and benzoic acid. A large number of catalysts were tried, among them being the oxides of Al, Bi, Cr, Mg., and many others. Some of these gave promise of good results. Tests so far gave a conversion of 10 per cent of the original toluene into benzaldehyde and 1.5 per cent into benzoic acid. Upon separation by distillation 75 per cent of the toluene is recovered.

W. C. TAYLOR described a new glass called "noviol," which absorbs the ultraviolet radiations, and can be used for many industrial purposes. One variety is used for arc welding glasses, another variety for filtering light in chemical works, and another in microscopic work under artificial light.

A paper on "Single and Multiple Effect Evaporators" was presented by OTTO MANTIUS. This paper will be printed in full in a later issue. It gives information of great value to those having evaporating prob-

lems. In the discussion of this paper it was brought out by Mr. Mantius that for caustic solutions the iron tubes in the evaporator should not contain more than 0.03 phosphorus. He said there was no one material for tubes which would be good for all liquors. Copper is too expensive at the present time to use, but makes very good tubes. Mr. Mantius said he had found difficulty in getting anyone to make tubes of the proper quality, but that experiments were being made for him by a manufacturer at the present time along this line.

The "Cheap Production of Alcohol" was discussed in a paper by ARTHUR N. BRECKLER. He said there were two uses for alcohol, viz.: as a raw material in the industries, and as a fuel. At the present time the largest uses of alcohol are in the hat and tobacco industries, and also since the war in the munitions factories. Mr. Breckler thinks the big future for alcohol is as a motor fuel. He said to compete it must be made for not over 10 cents per 160 proof gallon. In 1914 we produced 182,000,000 gal. of alcohol, which is about 5 per cent of our present gasoline consumption. This alcohol is mostly produced from grain, corn, malt, and rye. One other large source is black strap molasses, but to be a commercial proposition the black strap must not cost more than 5 cents per gallon. It is now selling at 12 and 14 cents, and is almost impossible to obtain, on account of the increasing demand for molasses. Other sources are wood waste and sulphite waste from pulp making. These so far have not achieved any great success, but offer possibilities. In considering an alcohol process the cost of coal and water costs for cooling must be considered. There are a lot of abandoned alcohol plants which have been unsuccessfully operated. Grain is too high to make alcohol from to compete as a motor fuel, and molasses is rapidly becoming too high. Other sources must be found.

An interesting paper on "The Use of the Cottrell Precipitator in Recovering Phosphoric Acid" was presented by W. H. ROSS, J. N. CAROTHERS, and A. R. MERZ, of which the following is an abstract.

An investigation on a semi-commercial scale has been made of the use of the Cottrell precipitator in recovering the phosphoric acid evolved in the volatilization method of treating phosphate rock by ignition with coke and silica in an electric furnace. A current of air which was passed over the charge in the furnace served the double purpose of oxidizing the fumes of phosphorus to phosphoric anhydride and of carrying the latter to the precipitator. In one series of experiments the fumes from the furnace before entering the precipitator were passed through a tower provided with baffle plates which had the effect of cooling down the gases to about ordinary temperature. In a second series of experiments the tower was cut out and the fumes passed almost directly into the precipitator at a temperature above 100 deg. In each case the phosphorus anhydride, which takes up water from the current of air passing through the furnace and also from the moisture driven off from the charge, is precipitated in the form of a solution of phosphoric acid. When the precipitation is made at temperatures above 100 deg., the acid obtained is not only more concentrated, but also of a higher degree of purity, with respect to volatile constituents than that recovered at lower temperatures.

The advantages of this method of collecting the phosphoric acid over the scrubbing tower method now in use are as follows:

(1) The equipment required is simple in construction and automatic in operation.

(2) The simplicity of the construction of the precipitating pipes decreases the difficulties arising from the corrosive action of the phosphoric and hydrofluoric acids evolved from the phosphate rock.

(3) The phosphoric acid recovered in this way is of a high degree of purity and is thus suited for direct use without further purification in those industries where a relatively pure acid is required.

(4) A more concentrated acid can be obtained in this way than by any other commercial process, and when this acid is used in the preparation of concentrated fertilizers, such

as mono-ammonium phosphate, a dry product may be obtained directly without the necessity of evaporating solutions, or of drying the resultant product.

This is the first time that the Cottrell precipitator has been used for the precipitation of a product which has been volatilized with a view to its recovery in this way.

Colloids

The Industrial Division met on Thursday in joint session with the Sections of Physical, Inorganic, and Biological Chemistry, which session took the form of a symposium on "Colloids."

On Wednesday morning the Biochemical, Physical and Inorganic Divisions held a joint session on "Colloids" in Havemeyer Hall, Columbia University. Several interesting papers were read presenting different phases of this interesting subject, which at present is receiving so much attention.

On Thursday morning the joint session of the Biological, Physical, Inorganic, and Industrial Divisions continued the symposium. A paper by Dr. CHARLES BASKERVILLE on the "Refining of Oils" was supplemented by experiments illustrating his process, which consists briefly in treating crude cotton, soya bean, and other oils with cellulose fiber (about 0.25 per cent by weight), adding a determined amount of caustic soda, heating, then adding a small percentage of sodium sulphate or carbonate and filtering. A more complete description of this process which is now being operated on a commercial scale was given in our issue of July 1, 1916.

A paper by Dr. COLIN G. FINK dealt with the "Relation between Chemical Composition and Electrical Resistance."

The paper describes a series of experiments carried out in support of the author's theory that the electrical conductivity of substances in general is primarily dependent upon the shape and distribution of the fundamental grains or particles composing the substances, and secondly, upon the presence or absence of thin films of secondary material ("cement") enveloping these ultimate grains.

T. R. BRIGGS discussed colloid chemistry as applied to the paint industry.

L. A. KEANE presented a paper on "Yellow Bricks." This paper was read by W. D. Bancroft.

The "Vulcanization of Rubber" was discussed by D. SPENCE. This paper gave the latest and most plausible theory of rubber vulcanization, proposed first by a Russian chemist, viz., that a definite rubber compound is formed which is distributed through the rubber forming a two-phase system having different properties than either the rubber or the rubber compound. Thus when using sulphur a rubber sulphide is formed which is distributed through the rubber.

W. D. RICHARDSON discussed the "Splitting of Fats" and A. W. DAVISON the "Absorption of Chromium by Hide Powder." Other papers were read on "Asphalt" by C. RICHARDSON, "Plaster of Paris" by L. A. KEANE, "Emulsions and Suspensions with Molten Metals" by H. W. GILLETT, "The Purification of Kaolin" by C. L. PARSONS, "Colloids in Glass" by ALEXANDER SILVERMAN, and "Fritting and Fusing" by W. D. BANCROFT.

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A series of industrial conferences was held each afternoon, commencing Wednesday, at which were discussed various subjects of importance such as dyes, glass, etc. A fuller account of these and of some of the other meetings is reserved for a later issue. The reception which was held Tuesday evening at the Hotel Astor and the banquet Friday evening at the Waldorf-Astoria were well attended by members of both the chemical and electrochemical societies, and other visiting chemists and engineers.

New York Meeting of American Electrochemical Society

The thirtieth general meeting of the American Electrochemical Society was opened on Wednesday, Sept. 27. Fittingly the opening session was held in the lecture room of the Chemical Exposition at the Grand Central Palace, as Wednesday was "Electrochemical Day" of the Exposition.

Dr. COLIN G. FINK, chairman of the New York Section of the society, presided.

Mr. ADRIAAN NAGELVOORT, one of the managers of the Chemical Exposition, made a felicitous little speech of welcome in which he spoke of electrochemists as live wires and of the automobile in the Electrochemical Society booth of the Exposition as just one example demonstrating clearly how electrochemical processes and products are revolutionizing the industries of the country.

PRESIDENTIAL OPENING ADDRESS

An address by the president of the American Electrochemical Society, F. A. J. FITZGERALD of Niagara Falls was then read by Dr. JOHN A. MATHEWS, as Mr. FitzGerald was unfortunately detained in Niagara Falls by sickness. Mr. FitzGerald's scholarly address is herewith given in full:

When I emigrated to the United States nearly a quarter of a century ago I was immensely struck with the great stress laid on the word "imported" when buying anything. The excellence of the goods would be freely explained by the salesman, but he generally reached a climax when he pointed out that they were "imported."

Before coming to this country I do not remember observing that excessive modesty was a characteristic of its citizens and yet the enormous respect paid to imported goods seemed to imply its existence.

Here, as everywhere else, we find that we can do better in many cases by using articles manufactured in other countries, but the mere fact of being imported is hardly a proper recommendation. Some years ago when in Germany I visited a large steel plant where the guide apologized for some rather antiquated rolling mill machinery which he showed me, but when we had looked at this he conducted me with pride to another mill where he said they had American machinery or at least machinery of American design. Again you may see shoe factories in England which are said to be very efficient establishments because they have American machinery. And so in various European countries you will find things are represented as having certain excellent qualities because they come from some place where such articles have a well deserved reputation, but I do not remember having ever heard of a thing being recommended just because it was imported.

Now the existence of an idea that because something is imported it must be of greater excellence obviously involves the tacit assertion that things made in this country are inferior. This attitude towards imported articles has, I think, been considerably modified in recent years, and as a means of bringing about this desirable modification, exhibitions such as this of our chemical industries are of immense value.

When the United States were sparsely inhabited and there were relatively few industries, they had to depend for many things on importation, and so it came about that an indiscriminating belief in the excellence of imported articles developed and this as regards many of these things exists even to-day.

Certainly in such matters it is not desirable to attempt to develop any spirit of nationalism which would induce us to support a home product which is inferior to the imported, but it is always well, even from a purely selfish point of view, to investigate what can be done at home before going abroad, and even if the home product is inferior to try and find the cause of its inferiority and then if possible to assist that industry to equal or excel the foreign product. Here again we find a valuable function of a national exposition such as this.

In various industries the United States is now in a position where it is well to the front or actually leader and I think we may assert without fear of contradiction that the electrochemical industry is one of these. The field is comparatively new and we did not start in it with the handicap

which existed in many of the older industries. In certain industries covered by the general term electrochemical we certainly have the foremost place—for example, in the manufacture of artificial abrasive materials. In other cases (such as the application of the electric furnace to steel) we have lagged behind until recently. Again in others we are a long way behind developments in Europe, as in the fixation of atmospheric nitrogen.

It is well worth while studying those subjects in which we are not or have not been in the front rank in order to determine why this is so. Thus a study of the development of the use of the electric furnace for the manufacture of steel seems to show that special conditions in Europe tended to stimulate the development there and that it was actually to our advantage that the pioneer work should be done there rather than here so that we have no cause to regret that while the pioneer work in this branch was being done in Europe we were busy in other directions.

On the other hand, the study of the development of electrochemical methods of nitrogen fixation shows a different reason for our backward position. Those not conversant with electrochemical history are apt to believe that this is altogether a foreign development, never having heard of the work of Bradley and Lovejoy at Niagara Falls more than twelve years ago. Here then we had a remarkable development that was arrested because of adverse environment. For in Europe when similar developments took place it was possible to obtain abundance of cheap electric power. When the question of "National Preparedness" is in everyone's mind we are asked what is to be done about the preparation of nitrates, for in this respect we are by no means ready, and the Committee on Public Relations of the American Electrochemical Society in its report to the administration on this subject recommends "a liberal water power policy, as the question of the cost of power is vital to several of the processes."

These examples show the value of a study of our position in the electrochemical industry and similar studies in other fields should also give profitable results. The electrochemist uses a great variety of materials and articles: chemicals, physical apparatus, electrical machinery, etc., some made in America, others abroad. It was with this in mind that the Electrochemical Society decided that at its meeting held here at the same time as this great National Exposition of Chemical Industries it would be of interest and value to devote a whole session to the subject "Made in America" as related to electrochemical interests.

This discussion of the subject should be useful in several ways. It may help to develop a more critical study of imported materials and articles, and this is very necessary, for it is a fact that we are often apt to be less critical of an imported than of a domestic article, and there can be no doubt that the foreign manufacturer often likes to unload on us materials which he could not sell at home.

As an example of this I may mention the advice I received from an eminent American physicist who gave me the address of a well known German manufacturer of thermometers; said he, "When you place your order tell him that you know what good thermometers are and that you don't want him to send any of the poor quality which German manufacturers think are quite good enough for American consumption."

In other words the discussion of "Made in America" will stimulate a more discriminating appreciation of imported articles.

Another useful end will be served if the discussion of it reveals why the domestic product does not give the satisfaction which the imported material does. This may develop much needed co-operation of the consumer and the producer. There has not been enough of this. If the domestic article is not satisfactory the consumer has been in the habit of throwing it out and using the imported article without having sufficiently long sight to see that it was worth while to co-operate with the producer in helping him to better his manufacture.

It is perhaps getting dangerously near a political question, which ought not to be political, to say that mutual co-operation of producer and consumer is in the long run of far more importance than protection, which is sometimes apt to encourage the manufacture of inferior articles.

Perhaps then, one of the greatest uses of such an exhibition as this is the way in which it brings together the manufacturer and the consumer to their mutual benefit and for this we surely owe a debt of gratitude to those responsible for it.

"Made in America" Session

The morning session of Thursday, held at the Hotel Astor, was devoted to the subject "Made in America," and turned out very interesting. Great credit is due

to Mr. L. E. Saunders, chairman of the "Made in America" committee, for having made the arrangements. Mr. F. A. Lidbury presided during the session.

Mr. L. E. SAUNDERS introduced the subject by a general statement of how the committee had proceeded and quoted different opinions concerning the question whether a "Made in America" movement should be carried on along the "slogan idea."

Mr. ACHESON SMITH then discussed this very question in an interesting paper. The use of such an expression as "Made in America" may induce the use of American-made goods through patriotic motives, but such an appeal would be limited to Americans and would be of doubtful value.

If, on the other hand, the expression "Made in America" is simply to focus the attention of people, both at home and abroad, upon the fact that the goods are made in America, it would seem axiomatic that such goods must be of the very highest possible quality and sold at a reasonable price, or the expression "Made in America," would soon be a warning against American-made goods instead of an argument therefor. If the slogan "Made in America" could be limited to goods of the highest possible quality, which would have to have the approval of some central body or governmental bureau before the makers were permitted to use such expression, the slogan might become a sort of hall mark for quality, which would in time induce many people to demand American-made goods upon the assumption that everything bearing the expression "Made in America" was of the highest quality. Unfortunately, it does not seem possible to establish standards by which every article of manufacture can be measured, nor any bureau to which it would be safe to give the power of granting or withholding permission to use "Made in America." If the manufacturers of the best goods produced in America should use the expression "Made in America," we would naturally expect others who had difficulty in selling their goods, owing to poor quality or unreliability, to use the same slogan as a cloak to enable them to gain a standing which they do not deserve. If this should continue to any great extent, and it seems that it would be a very probable tendency, the use of the expression "Made in America" would likely be of more harm than benefit to American goods, for the simple reason that comparatively few instances of inferior quality would become more widely known and be remembered longer than many times the number of cases of high quality goods which have given satisfaction. It would simply be a case of bad news traveling faster than good news.

The whole question of selling goods in foreign countries is one of economics, and not a question of national trade mark. As a nation the value of our imports must equal our exports, so we will probably continue to import the goods we do not produce, or which are of a better quality than we make, and we will continue to export the goods others do not make, or which are preferred owing to their quality. As other countries may commence at sometime to manufacture goods formerly imported, it would therefore seem evident that the only part of our foreign trade that is secure is the portion based on quality. If we manufacture and sell inferior articles, they cannot be a dependable part of our foreign trade.

One of the fundamental items in preparation for export trade is for a manufacturer to test his product in comparison with similar products made in other countries, and if his article does not prove to be the best, he should go back over his manufacture and leave nothing undone to make his output of a better quality than that of his competitors. Having thus made sure by actual test that his product is as good or better than competing articles, he should take pride in placing his own name and trademark thereon so that his product may be identified, and if he is then willing to stand squarely behind his product, he will have done the most important thing that can be done for himself and for the foreign trade of the United States. If the manufacturers are desirous of gaining or extending their trade in other countries, they should be willing to put their goods to the supreme test of actual comparison, and when their goods are able to stand up under such test, they are then prepared to enter the foreign field having their business based on the bed rock of quality. Any success which follows they will of course enjoy and the benefit to the United States will naturally ensue.

Mr. F. A. SCHRAMM of the Bureau of Standards was the next speaker, reviewing in an interesting way the

experience of the Bureau of Standards with apparatus and materials which are now being made in this country and were not made here before, at least to the extent of their present manufacture. He reviewed the progress made in the manufacture of balances, iron-nickel alloys for standards of measurements ("invar"), cloth for cement analysis, meters and other electrical instruments, thermometers and pyrometers. With respect to materials he discussed pure platinum for pyrometer work, optical glass and instruments, pure metals, chemical glassware, ceramic products, porcelain, and referred to the necessity of blending clays for crucible manufacture. It was a very interesting report of progress with an occasional word of helpful criticism. The author concluded by emphasizing the necessity of the use of the metric system for export trade.

Mr. L. E. SAUNDERS then reviewed the progress made in American manufacture of such products which concern more directly the electrochemical industry. He started with carbon electrodes.

Before the European War started, we cannot deny the fact that a large quantity was imported from various European countries. The number of replies to our inquiries from users has been extremely gratifying. Every user of whom we have inquired, has stated that it is possible to secure, in this country, large electrodes of as good a quality as was purchased abroad two years ago. There is, of course, a possible erroneous conclusion here. It has been brought to our attention that progress may have been made with the European manufacturers and as great an improvement may have resulted as has been experienced in this country. One user states that when the war started there were no carbons of large size to be compared with those of European manufacture. Another user states that some of our carbon manufacturers have been successful in improvement and others are not doing as well as they did when severe competition had to be met. Still another user says that they are unable to furnish any testimony in this respect as they have used nothing but American-made electrodes. Undoubtedly, these latter people would come in the class, favoring a slogan "Made in America," and the purchase of articles bearing that slogan, whatever their quality might be.

Some users have gone into detail in the matter of carbon electrodes, and have stated: First, that the perfection of manufacture is very high in our American-made carbons. Second, that the resistivity is even less than the best of European carbons and that annealing has been so perfectly done that breakage almost never occurs. This user is, of course, an enthusiast, for those of us who use carbon electrodes realize the Utopian nature of the last statement.

One of the complaints that has been made by a user is that the price of European electrodes delivered was about 40 per cent. less than the cost of the best American electrodes during the past year, and that there is no such difference in quality as to warrant such a difference in price. It is, perhaps, needless to point out that we do not know what the cost of European electrodes might now be delivered in the United States, but it is safe to say that it would not be the cost at which they were sold two years ago, and there is at least a question whether such a difference in price will occur again when the manufacturers meet in competition.

I turn now to the use of electrodes in the electrolytic field, and here, again, I am obliged to say that there has been no adverse testimony of American-made articles, in fact, they have so uniformly favored a single manufacturer, that it becomes embarrassing to make any statement. In only one instance has testimony come in where a carbon electrode has been used in wet electrolytic work and even in this case it is reported that those purchased in this country were preferable to those secured from abroad. All our other testimony on this subject states that graphite electrodes are used.

The next subject on our list, and one which necessarily is of a restricted nature, concerns the metal, platinum. One of our most prominent professors of electrochemistry has stated in a letter that no American-made platinum makes any pretense of being good. Other users state that platinum vessels have been supplied by American manufacturers containing so much iron and iridium that they cannot be used for accurate analytical work and are attacked when used on a large scale in other ways. This is a serious arraignment of American-made articles.

(Mr. Saunders referred to one reply he had received from

an American platinum manufacturer to the effect that competition of years had been successfully met by American-made articles, and that there has been no demand for quality of products that the American manufacturer has been unable to supply, and reference was made to a report of a committee of the American Chemical Society confirming that as good platinum can be obtained from American manufacturers as from abroad.)

I shall briefly mention, only in passing, the subject of ferroalloys. The quality of the products of this character made in this country have always been, almost from the time of the beginning of the industry, of the highest possible character. Unless we, here at this meeting to-day, hear something to the contrary from some one with experience, I think it can be safely said that so far as the article manufactured is concerned no hardship has been suffered with respect to ferroalloys. I do not refer now to the question of securing raw materials and ores which enter into their manufacture, but simply to the skill and art of the manufacturer itself.

I mention, in the same manner, the subject of electric steel. The testimony at hand has not been large, and it may be that something has escaped in the investigation. I know that special steels have been made abroad which, during the early part of the shortage here, could not be duplicated. This, I believe, is rapidly being overcome and I feel safe in saying, subject to correction at this meeting, that electric steel, in all qualities, made in this country has never been excelled.

Perhaps the matter on which we have received the greatest amount of testimony is in connection with the chemical glass industry. The users are, to a considerable extent, pessimistic. Quoting from a well-known college professor, the statement is made: "American glassware is very much inferior in workmanship, in most cases in quality, besides costing anywhere from two to five times as much." Another large user states that we cannot make a suitable glass without potassium and the proper silicates, nor without the proper clay materials for the pots, and these are not obtainable in this country. The same user is extremely pessimistic about remedying this situation. He states that in many cases abroad it is a family affair, the making of fine glassware, and the son follows in the father's footsteps, these men not being willing to leave their country, and when they do come, they can command better wages than the industry can afford to pay. Another user states that compared with Jena glass, certain American made glasses are more resistant to the action of both acids and alkalis, especially the latter, for example: When boiled in 10 per cent sodium hydroxide solution, its loss in weight was less than 60 per cent of that sustained by Jena glass under the same conditions. Its resistance to shock and to sudden changes of temperature seems to be somewhat better than certain imported glassware. Another user states that resistance to sulphuric acid was higher in the case of American glass than of the best imported glass. Still another user placed test tubes filled with distilled water in an autoclave and kept them there for 45 minutes at 12 lb. pressure. No trace of alkaline or acid substances was found in the water with a large number of indicators. Very few foreign glasses, it is stated, can withstand this test. On the other hand, one user states that he is unwilling to publish the data he has obtained on both glass and porcelain for patriotic reasons. This statement certainly should draw out something from those present here.

We have been furnished with a large amount of data by manufacturers and all are agreed that our greatest difficulties at present are with light blown glassware. While workers from abroad have been brought to this country, the demands are so heavy with the European supply cut off, that hardly a beginning has been made in meeting the demand. Wages for this class of labor have gone up on account of the great demand, so that prices have also increased. It may be said, however, that this kind of ware can be produced in this country and it is simply a question of quantity rather than quality that is troubling the user. The manufacturers of glassware have stated, in one case, that the linear thermal expansion has been reduced in the glass of his manufacture to just about half that of the imported glassware. He states that fewer constituents are contained in the glass, which may contaminate solutions in analytical and other delicate chemical work, for instance: This glass is free from the elements calcium, magnesium and zinc. Tests of a glassware for solubility in distilled water showed a very much smaller solubility than with the German glassware, kind not stated. This same manufacturer gives results of tests in regard to breakage on sudden cooling. The beakers are filled with paraffine, and heated to a desired point, then immersed in water at 15 deg. C. The temperature reached before fracture averages 253 deg. C. No data is given with

reference to beakers of foreign manufacture. Tests were also conducted in the way of resistance to fracture by dropping. The beakers are dropped from varying heights onto a 2-in. pine plank. The average height which these beakers withstood was 30.7 in. A large number did not break at 36 in., and were not carried further. These are tests which apparently are used to give a favorable comparison of American glassware against that of German make.

Still another manufacturer gives data on glass baking dishes which, to the writer's knowledge, were never imported from abroad. Therefore, the data are not exactly in order in this discussion.

Another manufacturer states that the element potassium has been eliminated from certain glasses resulting in the saving of a large amount of potassium carbonate, and that the glasses in many respects are superior to the old.

Another development is in optical glass. It is stated that a glass has been developed which is faintly yellowish in color and which absorbs all ultra violet rays and therefore is especially useful in the manufacture of glasses for electric furnace work.

Another manufacturer has stated that he has been able to manufacture a very limited line of glassware for laboratory use, but has been unable to extend his line on account of manufacturing conditions.

This testimony, both by the user and the manufacturer, seems to be overwhelmingly in favor of the conclusion that American made glassware can be secured which excels in numerous properties that which has been imported from abroad. The criticism in regard to price seems to me an improper one and the subject would be more properly discussed when competition again occurs.

Our next subject, and one which is of great importance, is that of chemical porcelain. Here we have again had much testimony, principally from the manufacturer. That there is a prejudice, however, may be seen in the statement of a prominent member of this society, as follows: "I certainly was surprised at the cracking of a small porcelain crucible I was heating. I could not find the crossed swords on the bottom. It probably would have had 'Made in America' on it if marked at all." By the testimony which follows, it would seem that even so high a recommendation as the crossed swords is not the ne plus ultra which this testifier would have us think. One man who states that he has used American made porcelain in four weeks of summer school, says that he has lost all idea of ever being able to secure good American porcelain. Turning from this pessimist for a moment, it is good to find such testimony, as the following:

Heating and cooling test, American-made porcelain against Royal Berlin, number cracked or crazed: In the case of Royal Berlin, one; American make, none. The test consisted in heating the sample to 1700 deg. Fahr. and then removing with a pair of steel tongs and tossing upon a steel plate in a draft. Next test, solubility in 25 per cent sodium hydroxide boiling for 6 hr.: American-made porcelain, 1.5 per cent; Royal Berlin, 1.8 per cent. Next test, effect of ferric oxide ignition on glaze: American make gained in weight, .001 per cent; Royal Berlin, .006 per cent.

Numerous other tests are reported, but comparison not being given, they are not quoted.

Certainly no pessimism is in order as the result of such tests. The greatest criticism that has been received on these articles is the long time it takes to secure them, and surely no one can say that this can refer to the quality of the articles. On the other hand, another user has stated that his bills for both glassware and porcelain have been cut in two by the use of American-made ware as compared to that of foreign made.

In the case of electrical instruments we believe that the situation has not changed since the war, as American-made instruments, by common consent, are the best in the world. Chemical balances are made with great success in this country; machinery used in the electrochemical industry has been nearly always secured here; microphotographic apparatus made here, it is stated, is far ahead of anything made in Europe. Articles like filter paper have been long made of high quality; microscopes of American manufacture cannot be beaten. Some other instruments which have been made abroad are being worked on now in this country.

A long and animated discussion followed. Mr. Hinckley discussed large carbon electrodes of American manufacture, Dr. Moore other carbon products (brushes, arc lamp carbons, etc.), and Mr. Beckman referred to the manufacture of arc lamp carbons on the Pacific Coast. Mr. Canby referred to the early production of pure nickel in this country, Mr. Scherl to American-made carbon brushes for electrical machinery.

Dr. Cushman emphasized that a sound judgment on the quality of a product can only be founded on the test of actual service, extending over years, and should not be based on specially devised short tests. Mr. Saunders said that he would not buy things on the manufacturer's reputation and that tests, even quickly made, were useful. Dr. Cushman replied he did not believe in the reputation of a manufacturer, but in the reputation of an article of established manufacture.

Mr. Colby spoke on platinum and emphasized that the production of any grade of platinum was not a question of ability of the American manufacturer. If the trade wants it, it can be had.

Mr. Saunders thought that in many complaints the real trouble was the short pocket-book of the college professor. If you are willing to pay the price, you can have what you want. Dr. Richards thought the problem was to get the same quality at the same price.

Messrs. Moore and M. B. Smith discussed American-made thermometers and the corrections necessary for the extent of stem immersion. Both agreed on the necessity of frequent calibrations.

Dr. Frary referred to the duty-free importations for universities as an important point in the problem. For the average class of students not exactly the same ware is needed as for an industrial laboratory.

Dr. Fink said the public had had a wrong impression as to the value of imported goods and said that the past few years had taught a valuable lesson. For instance, the value of American-made plate glass is now understood and appreciated.

Dr. Richards referred to the Guggenheim copper leaching plant in Chile, where magnetite electrodes are used. These were formerly imported from abroad, but now they make them themselves.

Dr. W. H. Walker thought that general hopefulness should prevail. We should give our manufacturers time and they will produce what we want.

Dr. Lyon said he had no trouble with getting American-made glassware and porcelain, but with filter paper. Dr. Richards said good filter paper was made in this country.

Mr. Acheson Smith emphasized that one of the main objects of the whole discussion was to bring manufacturer and consumer together.

Mr. Canby related an instance of co-operation between a Pueblo smelter and a Denver manufacturer of assaying apparatus which had produced great results.

The manufacture of graphite crucibles was also discussed and the necessity of blending American clays emphasized. Dr. Richards said the increase in the price of crucibles had greatly aided electric steel developments. Mr. Schramm thought many troubles with crucibles were due to improper handling. Mr. Smith thought that the shortage of stock had resulted in insufficient time being spent for annealing.

Thursday Afternoon and Friday Sessions

Limitations of space in the present issue force us to reserve accounts of the Thursday afternoon and Friday sessions for our next issue. The Thursday afternoon session was devoted to electrometallurgical papers and elicited some lively discussions on the non-corrosive properties of copper-steel versus pure iron and on various electroplating problems. In the Friday session the dry-cell and storage-battery papers were first presented. Dr. Hering's paper on high-temperature heat developed during electrolysis, elicited considerable discussion.

A smoker at the Hotel Astor on Thursday night was attended by between 800 and 900 chemists.

The convention is to be concluded on Saturday by a complimentary boat ride up the Hudson.

Can an American Potash Industry Be Established?

By Emil D. Koepping

To live people must consume certain products of the soil, and are thus dependent on agriculture. Potash is one of the three vitally important plant foods. It is usually present in abundance in most soils, but only a small percentage of that present is in an available condition. The balance is bound up in silicates, from which it is released only by extremely slow natural processes. A considerable amount of the potash present in the available condition is removed with each crop, causing depletion of the soil. No one plant food can substitute for the lack of another, so it becomes necessary to artificially replenish the supply. That this is now being realized is demonstrated by the fact that of the total production of potash between 85 and 90 per cent is used in agriculture. The tonnages used have been increasing, and will doubtless continue from year to year along with the increasing enlightenment of the farmer along the lines of scientific agriculture.

Potassium salts are indispensable to many industries, as practically every present-day industrial activity requires potash in some form. Photographers, dyers, painters, and many cleaners, bleachers, weavers and soapmakers use it. It is used in refrigeration, in producing preservatives, fireworks, gunpowder, matches, paper, glass and aniline dyes.

The industries consume at the present time about 14,000 tons per year (basis K₂O), while for agricultural purposes about 216,000 long tons are used.

The sources of potash are wood ashes, tobacco stems, cottonseed husks, refuse of beat sugar manufacture and wool washing. The amount available from these sources is very small compared to the 230,000 or more long tons annually required, and the United States, like all other countries, is dependent on Germany for its supply of soluble potash salts.

Other than wood ashes and vegetable refuse there are four potential sources of potash in the United States: subterranean brines and salt lakes in the West, kelp, feldspar, and known deposits of the alunite type. In addition to these there is the possibility that the sinking of bore holes in districts of proper geologic formation would lead to the discovery of beds identical with or similar to the Stassfurt deposits of Germany.

KELP

The possibilities of utilizing the giant kelp groves of the Pacific Coast are interesting. That the potash, which is often as high as 30 per cent of the ash, contained in kelp can be recovered is certain. In fact, potash is and has been for a long time past produced in the vicinity of Glasgow, Scotland, from a similar seaweed. The quantity produced is small, amounting to about 2000 tons per years.

The first problem to be solved before kelp could be used on a large scale as a source of potash is the method of harvesting and handling the wet kelp. Considerable difference of opinion exists on the subject. Some investigators maintain that it is impossible to handle this material in a profitable way, while others are just as certain that the operation is satisfactorily solved. The weight of evidence appears to be with the latter.

Many ways of utilizing the values of the kelp have been proposed. One of the simplest is to dry and grind the kelp,¹ in which form it is in itself a good fertilizer, supplying nitrogen, phosphorus, and potash. The kelp

readily decomposes in the soil, which is an advantage, as it aids in increasing the humus material.

Most of the other processes suggested are ones which aim to produce technically pure potassium chloride.

Filtration processes applied to green kelp are failures, because the fiberless character of the organic matter causes clogging of the filters. A British patent² aims to overcome this difficulty by pulping and then forcing the pulp under pressure through a heater and heat recuperator at a temperature sufficiently high to destroy the slimy water binding character of the organic matter, namely, about 170 deg. C. The pulp is then cooled and pressed. The expressed liquid is used for the pulping of fresh material, thus increasing the potash concentration. Potassium chloride and iodine are the products from the expressed liquors. The residue after further pressing and drying out is used as a solid fuel or distilled to form a gaseous fuel, in which case the final charred residue is suitable for use as a filtering and clarifying agent.

Other processes recommend preliminary drying of the material. About the only way in which this could be satisfactorily accomplished is in a rotary dryer, as if the material is heated without stirring it matts down and potassium chloride may be volatilizing from the surface while the interior of the mass is still quite cool.³

S. R. Oppenheim⁴ proposes drying kelp for the recovery of potash and other values in the following manner: A direct flame is applied to a thick layer of kelp in a charring furnace to ignite it, and after a considerable portion of the kelp near the flame is in a glowing condition the flame is discontinued and a down draft maintained through the kelp until the whole layer is charred. The temperature of the furnace walls is maintained below 350 deg. C., and care is taken not to incinerate the mass.

Once the values are separated from the plant, however it be accomplished, it is relatively simple to separate the sodium and potassium chlorides from each other.

Assuming a satisfactory solution of the technical problems, there still remain certain economic problems to be considered, which make it doubtful if kelp will develop into a source of supply of a large amount of potassium salts.

SUBTERRANEAN BRINES AND SALT LAKES

Many brines from all parts of the United States have been investigated as to the possibility of thus establishing a potash supply. The results of this extensive survey have been greatly disappointing. Many of these brines were found to contain not inconsiderable percentages of potash, but the concentration of potash is so low in comparison to the other salts, and the combination of salts such that it is not likely that the extraction of potash from them will ever be commercially possible.

The salts found in the Searles Lake basin in southeastern California are of a more promising character. The valley floor commonly known as Searles Lake has had a somewhat lengthy history. It was discovered by John W. Searles in 1862. At the time he was prospecting for gold and did not pay much attention to it. Later, when borax began to draw attention, he recognized the resemblance of some samples of this salt which were shown him to the materials he had seen while crossing the alkaline flat several years before. He, together with E. M. Skillings, located claims in

¹J. W. Turrentine, Am. Fert. 42, 37-42; also I. F. Laucks, Met. & Chem. Eng. 14,304.

²Brit. 1,766 Boberg, Testrup & Techno-Chem. Laboratories.

³F. K. Cameron, Chem. Eng. 22, 6.

⁴U. S. P. 1, 141, 482.

⁵J. W. Turrentine, U. S. Dep't Agric., Bur. Soils, Bull. 94.

February, 1873, on such portions of the marsh as he considered most valuable.

Whitman Symmes, in 1898, was the first to suggest that potash might become a profitable product of the deposit. It is said that at the time he located nearly the whole area with the object of working the underlying brine for borax, soda and potash. This enterprise lapsed for want of support.

In 1908 C. E. Dolbear located the whole deposit for the purpose of establishing there a soda ash industry. A plant was put in, but for some reason the whole equipment was allowed to become idle before any soda was shipped. The deposit again came into prominence in 1912, when the United States Geological Survey indicated it as a possible source of potash. Development work has been going on since that time. In April, 1915, the American Trona Corporation was actively engaged in constructing an experimental plant to handle 20,000 gal. of brine daily. It was expected at that time that the products would be on the market late in 1915, but so far as I know are not as yet being sold. However, delays in pioneering work of this character are to be expected.

A plant is also being constructed on the shores of Owen's Lake, California, for the production of potassium chloride. Owen's Lake is a shallow salt lake having an area of 97 square miles, as compared with 65 square miles for Searles Lake. However, the concentration of potash salts in Owen's Lake is very much lower than in Searles Lake.

It is reported¹ that solid potassium bearing salts have been discovered in depth in Texas. It is stated that one well at a depth of 875-925 ft. contained 87.24 per cent of solid material of which 9.23 per cent was potash. Another well at a depth of 1700 ft. contained 51.72 per cent of soluble material, and of this 10.50 per cent was potash. It is stated that borings from two wells contained a salmon red substance which showed 14 per cent potassium chloride upon analysis and resembled carnallite. This occurred at a depth of 900 ft. in a bed of rock salt which overlies three other salt beds measuring together several hundred feet in thickness. Apparently, though, these deposits are small lenses, as the reported average for twenty-six samples taken at depths varying from 800-1700 ft. is only 0.44 per cent K₂O.

ALUNITE

Alunite, an insoluble double basic sulfate, occurs massive near Marysville, Piute County, Utah.

There are practically no technical difficulties involved in the production of potassium sulfate, impure alumina and sulfuric acid from this material. But there is no ready market for sulfuric acid in southern Utah in normal times, so it would be necessary to either allow the sulfur dioxide and trioxide gases to escape into the air or condense them and discharge them into the streams. If allowed to escape into the air they might damage vegetation, and this would probably bring objections from the Federal authorities as the deposits are located in a forest preserve. To condense the gases and discharge them into the streams would create a menace to fish life, and this would most certainly be objected to by the State authorities. There is no considerable market for impure alumina.

Though alum has been produced from alunite, the Roman alum being an example, pure potassium sulfate never was until two Utah companies, the Utah Potash Company and the Mineral Products Corporation, placed their product on the market in 1915, the latter in October of that year.

The production has not been large so far, owing to

the unforeseen incidents which usually turn up in work of this character. The product is a high-grade sulfate, and it is to be hoped that production increases, as this is the only naturally occurring source of sulfate of potassium now known in the United States.

The Bureau of Soils² reports that ignited alunite may be used directly as a fertilizer. The percentage of potassium oxide in it is greater than in kainite.

FELDSPAR

The first experimental work on the recovery of potash from feldspar was done by Tilghman in 1845, and the first United States patent was obtained by Bickel in 1856. Investigation of this field has been carried on ever since. The recent work has been, in a general way, along four lines: first, use of natural agents, such as heat, bacteria, carbon dioxide, etc.; second, wet chemical methods; third, dry volatilization reactions, and, fourth, dry heat reactions, by which the potash is rendered water soluble.

Franklin G. Carpenter³ proposes to render the potash in feldspar available for plant food by intensely heating the feldspar, suddenly chilling in water to reduce it to an amorphous state, and finally grinding.

H. W. Foote and S. R. Scholes⁴ decompose feldspar by heating it together with an equal quantity of sulfuric acid and one-tenth as much calcium fluoride as feldspar in sealed containers at a temperature of about 140-150 deg. C.

The product is then leached with water and potash alum is obtained from which potassium sulfate and alumina can be prepared. The reaction is stated to decompose 88.9 per cent of the rock.

E. E. Dougherty⁵ proceeds along somewhat similar lines. In working with leucite he adds sufficient sulfuric acid to combine with the bases, and after adding 2 per cent of the weight of the mixture of hydrochloric acid heats the whole until it becomes pasty and until the greater part of the water present has been driven off. The temperature is then raised to 500 deg. C. and the heating continued to drive off all the hydrochloric acid and the remaining water. The hydrochloric acid driven off is passed into a fresh charge, which has been mixed with sulfuric acid. The water soluble sulfates are then recovered from the residue by lixiviation.

Most of the processes designed to volatilize the potash from feldspar also aim to produce cement.

W. H. Ross⁶ states that if feldspar is heated in an open receptacle at about 1400 deg. C. with lime that practically all the potassium is volatilized, leaving a material resembling Portland cement closely in composition and suitable for use as a cement.

H. E. Brown⁷ produces potassium chloride and cement by fusing feldspar in an inert or oxidizing atmosphere at about 1300 deg. C. with sufficient calcium chloride to combine with all the potassium present and with sufficient calcium carbonate to bring the CaO content of the product up to about 50 per cent and collecting the volatilized potassium chloride.

He also patents⁸ a method of improving the cementing properties of the product, which consists in adding magnesium sulfate to the molten product.

Many other investigators proceed along the same lines, producing cement and either potassium chloride or oxide. These processes are hardly commercial possibilities, as any attempt to supply the country's needs would result in overloading an already well supplied cement market.

¹U. S. Dept. Agric. Bur. Soils, Circ., 70.

²U. S. P. 959, 841.

³J. Ind. & Eng. Chem., 4, 377.

⁴U. S. P. 1, 148, 156.

⁵Orig. Comm. 8th Intern. Congr. Appl. Chem. 15, 217-29.

⁶U. S. P. 1, 123, 841.

⁷U. S. P. 1, 124, 238.

F. Thompson¹⁴ patents a process of obtaining potassium sulfate from feldspar by mixing 5 parts of it with 5 parts of niter cake and 1.8 parts of salt. This mixture is then heated for one to two hours at a bright red heat, thereby partially fusing the mass. The product is then cooled, ground and leached with water. The sulfates of sodium and potassium thus extracted are then to be separated by fractional crystallization. The yield is stated to be 80-90 per cent.

E. Hart¹⁵ proceeds in a somewhat different manner. He fuses one molecular proportion of feldspar with one molecular proportion of barium sulfate and two molecular proportions of carbon. The product of the fusion is then to be ground and the soluble constituents extracted by leaching with sulfuric acid. The same investigator describes another process,¹⁶ which is to fuse together feldspar, potassium sulfate and carbon in the molecular proportions of 4:4:2, a little excess of carbon being used. The product of fusion is to be finely ground, dissolved in dilute sulfuric acid leaving a residue of silica. The products are said to be (1) silica pure enough for use in pottery, (2) alumina, (3) potassium sulfate, and (4) a small quantity of potassium sodium carbonate used for making soft soap.

A. S. Cushman and G. W. Coggeshall¹⁷ have carried on experiments with their process on a semi-commercial scale and effect a recovery of about 75-80 per cent of the potash in the feldspar treated. The final product is an 80 per cent muriate. Briefly their process is as follows: One hundred parts of ground feldspar is mixed with 20 parts of lime. This mixture is then fed into a rotary mixer and is sprayed with calcium chloride solution. The calcium oxychloride formed causes the formation of "clumps" or aggregates about the size of a pea. These "clumps" are then passed through a rotary kiln heated to 1050-1150 deg. C. The burned "clumps" are then extracted with water, a 10 per cent solution of potassium chloride resulting. This is concentrated with flue gases to 80 per cent potassium chloride crystals. The process is continuous.

The engineering details of this process have been quite thoroughly worked out, and it is estimated that 80 per cent muriate can be produced by it at a cost of \$31.32 per ton. This figure allows a 20 per cent profit, based on the ante bellum prices of muriate. An outlet for the mineral by-product at a very nominal figure would materially reduce the cost of production of the potassium chloride.

A. H. Cowles¹⁸ renders the potash in feldspar available for plant food in a wholly different manner. His process is to heat phosphate rock and potash feldspar to the sintering temperature or higher. The proportions of phosphate rock and feldspar are adjusted so that the CaO and SiO₂ shall be in the molecular proportions of 2 and 1 respectively. The sintered product is then treated with sulfuric acid. The result being a fertilizer containing available potash and phosphorus.

C. W. Drury¹⁹ prepares a fertilizer from feldspar by heating it with lime and iron oxides at a high temperature. A somewhat similar process has been tried in Sweden.²⁰ The feldspar is mixed with coal and iron filings and heated in an electric furnace. The products are ferrosilicon and slag. The slag contains the potash in a more soluble form than the raw material. It is sold under the name of "electrokali." Field experiments carried out with this "electrokali" gave results equal to 78 per cent of the yields given by sulfate of potash.

So it would seem that an American potash industry on a large scale can be established. That it has not come into being is no doubt due to the fear of having to meet a cut in prices by the German producers, which it would hardly be able, in the present status of the art, to survive. Possibly in the future a process will be developed which will be able to meet any competition. When such a process becomes a reality we may look for the beginning of a great American potash industry.

Lockport, N. Y.

The Thermal and Pressure Decomposition of a Naphthene Base Oil in the Gas Phase

By Gustav Egloff, Thomas J. Twomey and Robert J. Moore

In the thermal and pressure decomposition of hydrocarbon oils in the gas phase, a general study¹ of the types of oils has been undertaken with a view to ascertaining the general direction of the reaction and to study the relative importance of the starting oils as to the formation of gasoline, unsaturated and aromatic hydrocarbons. The present communication covers the effect of temperature and pressure upon naphthene base oils in the formation of gasoline, unsaturated and aromatic hydrocarbons.

Scope of the Investigation

The two oils investigated were of naphthenic character, derived from two different oil fields and were studied with a view to determining the value of the oils and to further emphasize the importance of the character of the starting oil for the production of gasoline and the aromatic hydrocarbons, benzene, toluene and xylene and also the amount of unsaturation in the distillation cuts. The two oils were subjected to the same conditions of temperature and pressure in the gas phase. After treatment, the oils recovered were analyzed by distillation, specific gravity, sulphonation for unsaturation, and the aromatic hydrocarbons, benzene, toluene and xylenes were determined as the nitro derivatives.

The Type of Oils Used

The naphthene base oils used were derived from two different oil fields, and represented in the one case 24

¹ Rittman and Egloff, Met. and Chem. Eng., 14, 70, 1915.
Egloff and Twomey, Jour. Phys. Chem., 20, 121, 1916.
Ibid., 20, 515, 1916.
Egloff, Met. and Chem. Eng., 15, 125, 1916.
Egloff and Twomey, Met. and Chem. Eng., 15, 245, 1916.
Egloff, Twomey and Moore, Jour. Ind. Eng. Chem., 8, Oct. 1, 1916.
Ibid., Jour. Phys. Chem., 20, Oct., 1916.

TABLE I—THE PERCENTAGES OF RECOVERED OIL AND THE SPECIFIC GRAVITY OF THE RECOVERED OIL AT TEMPERATURES 550 DEG., 600 DEG., AND 700 DEG. C., AT ONE AND ELEVEN ATMOSPHERES PRESSURE

Temperature, deg. C.	Oil No. 1			
	550	600	650	700
Per Cent by Volume				
Per cent recovered oil	90.0	78.0	59.5	52.5
Specific gravity	0.843	0.843	0.853	0.894
ELEVEN ATMOSPHERES PRESSURE				
Per cent recovered oil	67.3	54.7	38.6	32.0
Specific gravity	0.852	0.879	0.948	0.955
Oil No. 2				
Temperature, deg. C.	One Atmosphere Pressure			
	550	600	650	700
Per Cent by Volume				
Per cent recovered oil	90.0	72.0	56.1	41.3
Specific gravity	0.848	0.850	0.874	0.939
Eleven Atmospheres Pressure				
Per cent recovered oil	83.7	63.8	47.5	30.7
Specific gravity	0.840	0.874	0.951	0.978

¹⁴ U. S. P. 995, 105.

¹⁵ U. S. P. 997, 857.

¹⁶ Trans. Amer. Ceram. Soc. 13, 683-8.

¹⁷ J. Ind. & Eng. Chem. 7, 2, p. 145.

¹⁸ U. S. P. 1, 126, 408.

¹⁹ Canadian Pat. 160, 257.

²⁰ Chem. Eng. 20, 3, p. 130.

per cent of the original crude oil and in the other 11 per cent. Twenty-five gallons of each oil was distilled with steam and direct heating until the oil, which we will for sake of convenience call number one, gave a distillate of 24 per cent. The other oil, we will designate as oil number two. Twenty-five gallons of this oil were distilled under the same conditions until 11 per cent came over. The residues of 76 and 89 per cent were valuable lubricating oils, and were utilized for that purpose. The oils number one and two, which were subjected to temperatures 550 deg., 600 deg., 650 deg. and 700 deg. C. at pressures of one and eleven atmospheres, analyzed before treatment as follows:

DISTILLATION ANALYSIS		
OIL	No. 1	No. 2
Specific gravity	0.843	0.847
Temperature, Deg. C.	Per Cent by Volume	
To 150	1.3	0.0
150 to 200	26.0	22.0
200 to 250	32.7	44.0
250 to 300	27.6	25.0
300 to 335	5.6	6.0
Residue	6.8	3.0
SPECIFIC GRAVITY		
To 150	0.838	0.832
150 to 200	0.846	0.844
200 to 250	0.850	0.853

Experimental Procedure

The experimental procedure consisted of passing a definite volume of the naphthalene base oil through an electrically heated steel tube at a carefully regulated rate of oil flow.² The starting oil was filtered before use and in each experiment 700 c.c. of oil were used. After subjecting the oil to different conditions of temperature and pressure the cracked oil was collected from the receiver, filtered free from carbon and the volume of the recovered oil noted. The pressure of eleven atmospheres used was built up by means of a compressor, using natural gas. The pressure after building up to

²Egloff and Twomey, Jour. Phys. Chem., 20, 121, 1916.

TABLE II—THE DISTILLATION CUTS OF THE RECOVERED OILS

OIL NO. 1				
ONE ATMOSPHERE PRESSURE				
Temperature, deg. C.	550	600	650	700
Per Cent by Volume				
To 95	3.6	6.6	9.7	10.9
95 to 120	3.9	5.2	9.7	8.4
120 to 150	10.1	12.5	13.1	13.6
150 to 175	6.7	12.3	9.5	10.7
175 to 230	30.5	22.4	32.4	28.4
230 to 270	26.1	11.4	12.5	6.3
270 to Pitch	9.9	5.7	6.3	5.5
Pitch	8.3	23.8	5.9	16.1
ELEVEN ATMOSPHERES PRESSURE				
Temperature, deg. C.	550	600	650	700
Per Cent by Volume				
To 95	7.8	12.0	13.5	16.5
95 to 120	8.4	11.8	15.6	16.4
120 to 150	14.2	17.0	13.9	11.4
150 to 175	13.4	12.1	7.6	3.9
175 to 230	24.1	20.5	—	—
230 to 270	13.1	11.9	—	—
270 to Pitch	6.1	4.7	—	—
Pitch	8.7	9.9	—	—
OIL NO. 2				
ONE ATMOSPHERE PRESSURE				
Temperature, deg. C.	550	600	650	700
Per Cent by Volume				
To 95	1.6	6.4	9.5	12.1
95 to 120	1.8	4.9	8.8	11.0
120 to 150	2.4	6.1	7.5	10.8
150 to 175	5.6	14.8	11.8	10.6
175 to 230	—	25.9	—	18.1
230 to 270	—	23.6	—	12.2
270 to Pitch	—	4.5	—	8.2
Pitch	—	11.5	—	11.4
ELEVEN ATMOSPHERES PRESSURE				
Temperature, deg. C.	550	600	650	700
Per Cent by Volume				
To 95	5.4	9.6	17.7	22.3
95 to 120	4.8	11.3	12.5	10.8
120 to 150	7.0	10.5	10.9	7.5
150 to 175	12.7	10.1	6.6	6.6
175 to 230	28.2	22.4	13.6	10.5
230 to 270	24.3	19.3	8.3	9.5
270 to Pitch	8.7	4.2	5.3	9.2
Pitch	7.0	9.7	25.1	23.6

the required atmospheres was shut off and was further maintained in the system by means of the decomposition products of the oil.

The temperatures to which the naphthalene base oil was subjected were 550 deg., 600 deg., 650 deg. and 700 deg. C. and two pressures of one and eleven atmospheres were used. The cracked oil was analyzed for its gasoline, unsaturation content and the aromatic hydrocarbons, benzene, toluene and xylene by means of the following tests:

1. Distillation of liquid reaction products by means of a Glinsky distilling head.

2. Specific gravity of the liquid reaction products by means of a Westphal balance at 15.5 deg. C.

3. The gasoline content was determined by means of distillation, specific gravity and unsaturation.

4. The unsaturation* was determined by means of

*Egloff and Twomey, Met. and Chem. Eng., 15, 247, 1916.

TABLE III—THE COMPARISON OF THE SPECIFIC GRAVITY OF THE DISTILLATION CUTS OF THE RECOVERED OILS

Temperature, deg. C.	OIL NO. 1			
	ONE ATMOSPHERE PRESSURE			
To 95	0.732	0.753	0.791	0.829
95 to 120	0.800	0.815	0.844	0.858
120 to 150	0.829	0.836	0.855	0.860
150 to 175	0.840	0.845	0.862	0.871
175 to 230	0.852	0.858	0.882	0.900
230 to 270	0.858	0.864	0.905	0.921
270 to Pitch	0.863	0.899	0.932	0.932
ELEVEN ATMOSPHERES PRESSURE				
To 95	0.746	0.786	0.856	0.871
95 to 120	0.825	0.851	0.867	0.869
120 to 150	0.845	0.857	0.867	0.869
150 to 175	0.848	0.863	—	—
175 to 230	0.873	0.894	—	—
230 to 270	0.893	0.925	—	—
270 to Pitch	0.906	0.945	—	—
OIL NO. 2				
ONE ATMOSPHERE PRESSURE				
Temperature, deg. C.	550	600	650	700
Specific Gravity				
To 95	0.770	0.749	0.798	0.854
95 to 120	0.815	0.815	0.842	0.867
120 to 150	0.824	0.827	0.849	0.872
150 to 175	0.839	0.848	0.867	0.879
175 to 230	—	0.800	—	0.933
230 to 270	—	0.873	—	0.976
270 to Pitch	—	0.905	—	0.998
ELEVEN ATMOSPHERES PRESSURE				
To 95	0.734	0.773	0.805	0.873
95 to 120	0.804	0.848	0.870	0.870
120 to 150	0.823	0.856	0.869	0.870
150 to 175	0.845	0.867	0.876	0.879
175 to 230	0.855	0.890	0.945	Naphthalene
230 to 270	0.866	0.928	0.984	Naphthalene
270 to Pitch	0.883	0.970	0.998	Anthracene

TABLE IV—THE PERCENTAGES OF OLEFINS IN THE DISTILLATION CUTS

Temperature, deg. C.	OIL NO. 1			
	ONE ATMOSPHERE PRESSURE			
To 95	35	50	46	31
95 to 120	29	31	40	15
120 to 150	22	30	40	12
150 to 175	25	52	35	—
ELEVEN ATMOSPHERES PRESSURE				
To 95	40	36	15	10
95 to 120	38	29	10	6
120 to 150	28	20	6	—
150 to 175	48	—	—	—
OIL NO. 2				
ONE ATMOSPHERE PRESSURE				
Temperature, deg. C.	550	600	650	700
Per Cent by Volume				
To 95	47	54	51	36
95 to 120	34	31	24	10
120 to 150	30	19	17	10
150 to 175	20	14	22	16
ELEVEN ATMOSPHERES PRESSURE				
To 95	45	41	10.5	12
95 to 120	34	32	4.5	7
120 to 150	21	11	6.5	8
150 to 175	20	20	—	—

1.84 specific gravity C. P. sulphuric acid, Babcock, test bottles and centrifuge.

5. The percentage of benzene, toluene and xylene was determined by means of distillation, specific gravity and nitration.

A. THE EFFECT OF TEMPERATURE AND PRESSURE ON THE PER CENT OF RECOVERED OIL AND THE SPECIFIC GRAVITY OF THE RECOVERED OIL AT TEMPERATURES 550 DEG., 600 DEG., 650 DEG. AND 700 DEG. C., AT ONE AND ELEVEN ATMOSPHERES PRESSURE

The percentage of recovered oil from oil number one for both pressures used showed a marked decrease with increase in cracking temperature. At atmospheric pressure the amounts recovered ranged from 90 per cent at 550 deg. to 52.5 per cent at 700 deg. C.; while at eleven atmospheres pressure the same temperatures showed a range of 67.3 to 32.0 per cent respectively.

This decrease in amount recovered with increase in temperature is to be expected, considering the greater decomposition taking place at the higher temperatures, the tendency being to go completely to carbon and hydrogen as the temperature increases.

The amount of decomposition is further manifested by the specific gravities of the recovered oils which, for both pressures used, gave higher values with increased cracking temperatures.

At 550 deg. and atmospheric pressure, where 90 per cent were recovered, the specific gravity, 0.843, was identical with that of the starting oil, while at 700 deg.

where only 52.5 per cent were recovered, the specific gravity showed the maximum of 0.894.

For the same temperature of cracking, the increased-pressure runs in each case yielded lower percentages of recovery than the run at atmospheric pressure. And the recovered oil from the pressure runs showed for each temperature a much higher specific gravity than the recovered atmospheric-pressure oils.

Oil number two under the same conditions of temperature and pressure gave percents of recovery uniformly higher, with one exception, at 700 deg. C. and eleven atmospheres. The specific gravity showed results somewhat similar. All hydrocarbon oils would tend to converge to the same percentage of recovered oil, as the temperature of decomposition tends toward the formation of the ultimate products, carbon and hydrogen.

B. THE DISTILLATION CUTS OF THE RECOVERED OILS

The most striking difference shown by both oils used in the comparison of one atmosphere and eleven atmospheres is the larger percentage distilling below 150 deg. C. in each case from the runs at eleven atmospheres pressure.

For the runs at atmospheric pressure the fractions below 150 deg. C. yield, with one exception, larger percentages with increased temperature of the cracking process.

Under eleven atmospheres pressure the cuts to 150 deg. C. increased with higher cracking temperature from 30.4 per cent at 550 deg. to 44.3 per cent at 700 deg. C.

The cuts above 150 deg. C., however, yielded uniformly lower percentages with increasing temperature, while the pitch made up the difference by increasing in general with increased temperature.

The same tendency of lower boiling-point hydrocarbon formation is shown by both oils, with increase of temperature and pressure.

C. THE COMPARISON OF THE SPECIFIC GRAVITY OF THE DISTILLATION CUTS OF THE RECOVERED OILS

One of the most significant facts to be noticed in comparing these figures is that in every case the specific gravity of the distillation cuts from the eleven-atmospheres-pressure runs is higher than the specific gravity of the corresponding cut of the atmospheric-pressure runs, using oil number one. This would indicate a greater formation of lower boiling-point paraffin hydrocarbons at atmospheric pressure with higher aromatic formation as the pressure is increased to eleven atmospheres.

Increase of cracking temperature at both pressures used yielded uniformly oils of higher specific gravity, while in each case the specific gravity of high-pressure run was higher than that of the corresponding cut of the atmospheric-pressure run.

TABLE VI—THE PERCENTAGES OF BENZENE, TOLUENE AND XYLENE ON BASIS OF OIL USED

OIL NO. 1						
ONE ATMOSPHERE PRESSURE						
Temperature, deg. C.	550	600	650	700		
Per Cent by Volume						
Benzene	0.3	1.4	4.3	7.5		
Toluene	2.0	3.0	7.9	6.7		
Xylene	6.3	8.6	11.4	12.3*		
ELEVEN ATMOSPHERES PRESSURE						
Temperature, deg. C.	550	600	650	700		
Per Cent by Volume						
Benzene	1.3	4.9	11.5	15.6		
Toluene	5.7	10.0	15.6	16.1		
Xylene	11.0	14.8	13.6	11.2		

*Probably experimental error.

OIL NO. 2						
ONE ATMOSPHERE PRESSURE						
Temperature, deg. C.	550	600	650	700		
Per Cent by Volume						
Benzene	1.0	1.2	4.7	10.2		
Toluene	2.2	3.0	7.1	10.8		
Xylene	2.6	3.7	6.1	4.8		
ELEVEN ATMOSPHERES PRESSURE						
Temperature, deg. C.	550	600	650	700		
Per Cent by Volume						
Benzene	0.5	3.2	16.2	21.3		
Toluene	2.5	9.5	12.5	10.8		
Xylene	4.0	9.2	10.8	7.5		

TABLE VII—THE PERCENTAGES OF GASOLINE IN THE RECOVERED OIL

OIL NO. 1						
ONE ATMOSPHERE PRESSURE						
Temperature, deg. C.	550	600	650	700		
Per Cent gasoline	17.6	24.3	32.5	32.9		
ELEVEN ATMOSPHERES PRESSURE						
Temperature, deg. C.	550	600	650	700		
Per cent gasoline	30.4	40.8	43.0	44.3		
OIL NO. 2						
ONE ATMOSPHERE PRESSURE						
Temperature, deg. C.	550	600	650	700		
Per cent gasoline	5.8	16.4	25.8	33.9		
ELEVEN ATMOSPHERES PRESSURE						
Temperature, deg. C.	550	600	650	700		
Per cent gasoline	17.2	31.4	41.1	40.6		

With one exception oil number two indicated the same general characteristics of increase of specific gravity of the distillation cuts with increase of pressure. The exception noted was at temperature 550 deg. C.

From table V it can be seen that this fraction is exceptional in giving a lower percentage of benzene than the atmospheric-pressure run. This would account for the lower specific gravity.

D. THE PERCENTAGES OF OLEFINS IN THE DISTILLATION CUTS

The percentage of olefins present in the benzene cut (to 95 deg. C.), the toluene cut (95 deg. to 120 deg. C.), the xylene cut (120 deg. to 150 deg. C.), and the methylbenzene cut (150 deg. to 175 deg. C.), in conjunction with the specific gravity value, gives a criterion upon which to judge the amount of treatment necessary to obtain products free from unsaturation. The olefins are readily removed by concentrated sulphuric acid, esterification, addition of the halogen acids or halogens themselves, or by hydrogenation.

In the benzene cut in both oils the olefin content reaches a maximum and then decreases with increase of temperature at one atmosphere pressure; while at a pressure of eleven atmospheres the percentage of olefins decreases with increase of temperature.

The percentage of olefins in the toluene cut increases to a maximum in both oils and then decreases as the temperature increases, but with increase of pressure under the same conditions of temperature there is a sudden drop in the per cent of olefins between 600 deg. and 650 deg. C., which seems to be a critical temperature range for olefin formation under a pressure of eleven atmospheres with these two oils.

At atmospheric pressure the xylene and trimethylbenzene cuts exhibit the same tendency to olefin formation as the benzene and toluene cuts. At a pressure of eleven atmospheres the percentage of olefins in the cuts, xylene and trimethylbenzene decreases with increase of temperature.

In general it is to be noted that the greatest percentage of olefin formation occurs in the benzene cut; and decreases gradually in the toluene and xylene cuts. The trimethylbenzene cut, however, showed with three exceptions, an increase in the percentage of olefins present. The various theoretical views and experimental work as to the mechanism of the olefin reaction has been taken up by the subjoined list of workers.⁴ No clear-cut experimental evidence, however, has as yet been brought forward by the experimenters in the field of hydrocarbons to settle the question.

E. THE PERCENTAGE OF BENZENE, TOLUENE AND XYLENE IN THE RECOVERED OIL

The percentage of benzene increased in both oils with increase of temperature and pressure. The maximum formation in oil number one being 15.6 per cent and in oil number two 21.3 per cent, both at 700 deg. C.

⁴Wohl, Dinglers Polytech. Jour., 177, 69.
Thorpe and Young, Proc. Royal Soc., 21, 184. Liebig's Ann., 165, 28. Chem. News, 25, 174, 1871.
Prunier, Ber., 6, 72, 1873.
Armstrong, Jour. Soc. Chem. Ind., 3, 462, 1884.
Gawaloski, Oesterr. Chem. Tech. Ztg., 70, 1910.
Brooks and co-workers, Jour. Ind. Eng. Chem., 7, 180, 1915.
Jour. Franklin Inst., 180, 653, 1915. Jour. Am. Chem. Soc., 38, 393, 1916.
Brochet, Compt. Rend., 114, 60, 1892.
Lewes, Jour. Soc. Chem. Ind., 11, 584, 1892.
Armstrong and Miller, Jour. Chem. Soc., 49, 74, 1886.
Norton and Andrews, Am. Chem. Jour., 5, 1, 1886.
Tocher, Jour. Soc. Chem. Ind., 13, 231.
Haber, Jour. Gasbel, 1896, 377, 395, 435, 452, 799, 813, 830. Be-
richte, 29, 2691, 1896.
Kramer and Spillker, Berichte, 33, 2205, 1910.
Worstell and Burwell, Am. Chem. Jour., 19, 815, 1897.
Hempel, Gasbel, 1910, 53, 77, 101, 137, 155.
Hall, Gas World, 62, 187, 1915.
Ipatiew and Dowgilewitz Berichte, 44, 2987, 1911.
Purgeas and Wheeler, Jour. Chem. Soc., 105, 131, 1914.
Eglioff and Twomey, Met. and Chem. Eng., 14, 247, 1916.

and eleven atmospheres as the working pressure.

In all cases except one, under the same temperature conditions an increase to eleven atmospheres pressure increased the formation of benzene in the recovered oils.

At 650 deg. C. and one atmosphere in oil number one and in oil two at the same temperature and eleven atmospheres, the formation of toluene reached a maximum in two cases.

The percentage of xylene in the recovered oil increased to a maximum in three cases and then decreased.

The following figures bring out forcibly the wide differences in the total per cent of benzene, toluene and xylene resulting under the same conditions of temperature and pressure from the two starting oils.

THE TOTAL PER CENTS OF THE AROMATIC HYDROCARBONS BENZENE, TOLUENE AND XYLENE IN THE RECOVERED OIL

Temperature, deg. C.	ONE ATMOSPHERE PRESSURE			
	550	600	650	700
Oil No. 1	Per Cent by Volume 8.6	13.0	23.6	26.5
Oil No. 2	5.8	7.9	17.9	25.8
ELEVEN ATMOSPHERES PRESSURE				
Oil No. 1	18.0	29.7	40.7	42.9
Oil No. 2	7.0	21.9	39.5	39.6

This again emphasizes the great importance of the constituents of the starting oil in the thermal and pressure decomposition for the formation of benzene, toluene and xylene.

F. THE PERCENTAGES OF BENZENE, TOLUENE AND XYLENE ON BASIS OF OIL USED

The two naphthalene base oils used in these experiments have yielded higher percentage formation of the aromatic hydrocarbons benzene, toluene and xylene upon the basis of oil used for production, than any other

TABLE VIII—THE PERCENTAGES OF GASOLINE ON BASIS OF OIL USED AND THE SPECIFIC GRAVITY OF THE GASOLINE

Temperature, deg. C.	OIL NO. 1			
	ONE ATMOSPHERE PRESSURE			
Per cent gasoline	550	600	650	700
Specific gravity	0.800	0.800	0.817	0.839
ELEVEN ATMOSPHERES PRESSURE				
Per cent gasoline	20.4	26.2	16.7	14.2
Specific gravity	0.814	0.833	0.863	0.870
OIL NO. 2				
Temperature, deg. C.	ONE ATMOSPHERE PRESSURE			
	Per Cent by Volume	550	600	650
Per cent gasoline	5.3	11.8	14.5	15.0
Specific gravity	0.800	0.810	0.815	0.860
ELEVEN ATMOSPHERES PRESSURE				
Per cent gasoline	11.4	20.1	19.5	12.4
Specific gravity	0.800	0.825	0.860	0.870

TABLE IX—THE PERCENTAGES OF OLEFINS IN THE GASOLINE CUT

Temperature, deg. C.	OIL NO. 1			
	ONE ATMOSPHERE PRESSURE			
Per cent olefins	550	600	650	700
Per cent olefins	28.0	37.5	42.3	18.6
ELEVEN ATMOSPHERES PRESSURE				
Per cent olefins	35.2	28.1	10.3	8.2
OIL NO. 2				
Temperature, deg. C.	ONE ATMOSPHERE PRESSURE			
	Per Cent by Volume	550	600	650
Per cent olefins	35.9	35.4	34.2	19.3
ELEVEN ATMOSPHERES PRESSURE				
Per cent olefins	32.0	27.6	8.6	12.3

petroleum oil as far as the authors' experience is concerned or from values which are found recorded in the literature.

Since the naphthalene series hydrocarbons are saturated polymethylenes these experiments lend added evidence to the general theory that one of the methods of aromatic hydrocarbon formation from petroleum oils is by dehydrogenation of naphthalenes.

The data show the course of the reaction in the formation of dimethylbenzene or xylene, methylbenzene or toluene and benzene. The evidence is quite clear that the higher methyl derivatives of benzene form first and then decompose to lower methyl derivatives and then to benzene.

Other experimental work⁵ has shown that benzene decomposes to diphenyl, to naphthalene, to anthracene, and finally to carbon and hydrogen.

The data in Table VI for both oils used show maximum formation of xylenes as follows: at atmospheric pressure maximum formation of xylene occurs at the temperature of 650 deg. C., oil number one yielding 6.8 per cent and oil number two 3.4 per cent. At eleven atmospheres pressure, however, both maxima occur at 600 deg. C., oil number one giving 8.1 per cent and oil number two 5.9 per cent.

Coincident with increase of xylene formation, toluene and benzene increase, but not so rapidly until the xylene maximum is approached. Here xylene falls off and toluene and benzene form at the expense of it until toluene reaches its maximum. Here the benzene forming at the expense of toluene approaches its maximum. The maximum formation of xylene, 5.9 per cent, was at eleven atmospheres and 600 deg. C.; for toluene

at the same temperature 6.1 per cent and for benzene 7.2 per cent at 700 deg. C.

The evidence is unmistakable from this and other work⁶ of the thermal and pressure decomposition of pure aromatics that the course of reaction in aromatic hydrocarbon formation is as follows: Higher methyl derivatives of benzene as xylene to lower methyl derivatives of benzene, as toluene to benzene, and from other experimental work, benzene to diphenyl, to naphthalene, to anthracene, to carbon, and finally hydrogen.

Oils number one and two will give for every 100 gal. of oil thermolized under maximum-formation conditions the following percentages of aromatics:

OIL NO. 1					Total per Cent Aromatic Hydro- carbons
Per Cent by Volume	Benzene	Toluene	Xylene		
One atmosphere and 650 deg. C	2.6	4.7	6.8	14.1	
Eleven atmospheres and 600 deg. C	2.7	5.5	8.1	16.3	
OIL NO. 2					
One atmosphere and 700 deg. C	4.2	4.5	2.0	10.7	
Eleven atmospheres and 650 deg. C	7.2	5.9	5.1	18.2	

The data just preceding again emphasizes the high importance of the starting oils in thermal and pressure decomposition. Although the distillation analysis and specific gravity values of the two starting oils are quite similar, yet upon subjection to the same temperature and pressure conditions they give widely different yields of products.

The statement so frequently made in oil cracking circles that the starting oil is immaterial and that the temperature of reaction is of primary importance is not valid, since all the evidence at hand upon the thermal decomposition of hydrocarbon oils indicates clearly, as do the present data, that the starting oil is of high significance in such work.

G. THE PERCENTAGE OF GASOLINE IN THE RECOVERED OIL

Gasoline formation in the recovered oil at atmospheric pressure increased with increase of temperature from 17.6 per cent at 550 deg. to 32.9 per cent at 700 deg. C. in oil one, while under the same conditions oil two gave with one exception, much lower percentages, these ranging between 5.8 and 33.9, the latter per cent being the exception cited.

Increase of pressure had a great effect upon the gasoline formation in increasing the yields in every case, in one instance almost 300 per cent.

In oil one the per cent of gasoline at eleven atmospheres ranged between 30.4 and 44.3; while oil two under the same conditions gave a percentage yield between 17.2 and 41.1.

Upon the basis of gasoline formation in the recovered oil, oil number one gave uniformly higher per cents than oil number two, with a single exception. This exception was at 700 deg. C. and atmospheric pressure where oil number one gave 32.9 per cent gasoline and oil number two gave 33.9 per cent.

H. THE PERCENTAGE OF GASOLINE ON BASIS OF OIL USED AND THE SPECIFIC GRAVITY OF THE GASOLINE

Upon the basis of oil used for production the percentage of gasoline formation for oil one at atmospheric pressure gave values ranging between 15.8 and 19.3, while oil number two under similar conditions of temperature and pressure gave percentages of 5.3 to 15.0. It can be readily seen that oil number one gave a yield of

⁵Berthelot, Zeit. Chem., 707, 1866.
Schultz, Liebig Ann., 174, 201, 1874.
Ber., 9, 547, 1876.
Aronheim, Ber., 9, 1898, 1876.
Smith, Ber., 12, 722, 1879.
Hübner, Ann., 209, 339, 1881.
LaCoste and Sorger, Ann., 230, 5, 1885.
Berthelot, Ber., 5, 682, 1872.
Ipatieff, Jour. Russ. Phys. Chem., 39, 681, 1907.
Smith and Lewcock, Jour. Chem. Soc., 101, 1453, 1912.
Ferko, Ber., 20, 660, 1887.
McKee, Jour. Soc. Chem. Ind., 271, 403, 1904.
Haber, Ber., 29, 2691, 1896.
Rittman, Byron and Egloff, Jour. Ind. Eng. Chem., 7, 1019, 1915.
Hollings and Cobb, Gas World, 60, 879, 1914.

TABLE X—THE PERCENTAGES OF OLEFINS ON BASIS OF OIL USED FOR PRODUCTION

OIL NO. 1				
ONE ATMOSPHERE PRESSURE				
Temperature, deg. C	550	600	650	700
Per cent olefins	4.3	6.8	8.1	3.2
ELEVEN ATMOSPHERES PRESSURE				
Per cent olefins	6.9	6.0	1.6	1.1

OIL NO. 2				
ONE ATMOSPHERE PRESSURE				
Temperature, deg. C	550	600	650	700
Per cent olefins	1.9	4.2	4.5	2.3
ELEVEN ATMOSPHERES PRESSURE				
Per cent olefins	5.4	5.5	1.7	1.5

TABLE XI—THE PERCENTAGES OF THE STARTING OIL, DECOMPOSED TO FORM CARBON AND GAS

OIL NO. 1				
ONE ATMOSPHERE PRESSURE				
Temperature, deg. C	550	600	650	700
Per cent carbon and gas	10.0	22.0	40.5	47.5
ELEVEN ATMOSPHERES PRESSURE				
Per cent carbon and gas	32.7	45.3	61.4	68.0

OIL NO. 2				
ONE ATMOSPHERE PRESSURE				
Temperature, deg. C	550	600	650	700
Per cent carbon and gas	10.0	28.0	43.9	58.7
ELEVEN ATMOSPHERES PRESSURE				
Per cent carbon and gas	16.3	36.2	52.5	69.3

⁶Rittman, Byron and Egloff, Jour. Ind. Eng. Chem., 7, 1019, 1915.

gasoline as much as 300 per cent greater than oil two. Moreover the specific gravity of the gasoline cuts of oil one gave values between 0.800 and 0.839; while oil two ranged between 0.806 and 0.860.

When the pressure was increased to eleven atmospheres under the same temperature conditions, the percentage of gasoline formation increased greatly. The maximum was found to occur in oil one at 26.2 per cent and specific gravity 0.833, while the maximum for oil two gave 20.1 per cent and specific gravity of 0.825.

Pressure not alone increased the gasoline formation but also the specific gravity of the gasoline fraction, this being primarily due to the increased aromatic formation.

The gasoline cut contained unsaturated hydrocarbons which were readily removed by sulphuric acid treatment, giving a clear water-white oil with aromatic odor and upon standing no deposition of resinous material.

I. THE PERCENTAGE OF OLEFINS IN THE GASOLINE CUT

In oil one the percentage of olefins in the gasoline cut to 150 deg. C. increased to a maximum of 42.3 per cent at one atmosphere and 650 deg. C.

With increase of pressure to eleven atmospheres the percentage of olefins decreased with increase of temperature, the percentages ranging between 35.1 and 8.2.

Oil number two gave a lower average per cent of unsaturated compound formation. The maximum of 35.9 per cent formation of unsaturated hydrocarbons occurred at atmospheric pressure and 550 deg. C. and the minimum of 8.6 per cent at 650 deg. C. and eleven atmospheres.

J. THE PERCENTAGE OF OLEFINS ON BASIS OF OIL USED FOR PRODUCTION

The effect of temperature upon the formation of unsaturated hydrocarbons in oil one at atmospheric pressure was to increase the percentage of unsaturated on the basis of oil used to a maximum of 8.1 as the temperature increased from 550 deg. to 650 deg. C.

The maximum in oil two occurred at the same temperature, giving a value of 4.5 per cent.

The minima for this oil gave 1.9 and 2.3 per cents, while oil one gave minima under the same conditions of thermolization of 4.3 and 3.2 per cents.

The effect of pressure upon the unsaturated hydrocarbon content of the oils upon basis of oil used for production is not so great as that of temperature, although in general, from the data, an increase of pressure decreases the unsaturated hydrocarbon formation.

But the pressure at *lower temperatures* increases the unsaturation formation.

This is not a general phenomenon, for in most of the recorded data upon the effect of pressure upon decomposition of hydrocarbon oils the effect seems to decrease the formation of unsaturated hydrocarbons.¹

Oil number one evidenced a greater tendency toward the formation of hydrocarbons absorbed by sulphuric acid than oil two. Under the same conditions of temperature and pressure oil one gave as high as 225 per cent greater yield of unsaturated hydrocarbons than oil two.

K. THE PERCENTAGE OF THE STARTING OIL DECOMPOSED TO FORM CARBON AND GAS

The thermal and pressure decomposition of the starting oil number one, to form gas and carbon, increased with increase of temperature and pressure. At 1 atmosphere the percentage decomposed ranged between 10 and 47.5 per cent as the temperature increased from 550 deg. to 700 deg. C. At 11 atmospheres the per-

centage of oil decomposed to form carbon and gas increased from 32.7 to 68.0 per cent under the same temperature conditions.

Oil number two at 3 temperatures and atmospheric pressure decomposed more readily to gas and carbon than oil number one. With increase of pressure the stability of oil number two was much greater, with the exception of one run at 700 deg. C., where a slight increase was noted in gas and carbon formation.

Conclusions

1. Two naphthalene base oils were subjected to temperatures of 550 deg., 600 deg., 650 deg., and 700 deg. C. and to two pressures of 1 and 11 atmospheres. The decomposition products of the oils to be studied were gasoline, unsaturates, benzene, toluene, and xylene formation.

2. The two naphthalene base oils, although somewhat similar in characteristics as to distillation and specific gravity analysis, gave widely different percentage yields of gasoline, unsaturates, benzene, toluene, and xylene under the same conditions of temperature and pressure. This emphasized the importance of the starting oils in cracking phenomena when yields of certain types of hydrocarbons are desired in maximum quantity.

3. Increase of temperature and pressure increased the decomposition of the starting oils. At the same temperatures an increase to 11 atmospheres gave a lower percentage yield of recovered oil. The specific gravity of the recovered oils increased with increase of temperature and pressure.

4. For every 100 gal. of oil used the maximum percentages of aromatic formation at atmospheric pressure and 650 deg. C. gave a total for benzene, toluene and xylene of 14.1 per cent. The individual aromatic hydrocarbon percentage upon the basis of 100 gal. of oil used gave for benzene 2.6 per cent, for toluene 4.7 per cent, and for xylene 6.8 per cent. At 11 atmospheres the total percentage formation at 650 deg. C. was 18.2, and for the individual aromatic hydrocarbons, for benzene 7.2 per cent, for toluene 5.9 per cent, and for xylene 5.1 per cent.

5. At atmospheric pressure the maximum percentage yield of gasoline upon basis of 100 gal. used was 19.3 per cent at 650 deg. C. With increase of pressure to 11 atmospheres, and a temperature of 600 deg. C., the yield increased to 26.2 per cent. Increase of pressure is favorable for gasoline or low-boiling-point hydrocarbon formation.

6. The percentages of olefins or unsaturates in the gasoline cut to 150 deg. C. ranged between 8.6 per cent and 42.3 per cent. Increase of pressure decreases the formation of olefins in the gasoline cut.

7. The percentage of starting oil decomposed to form carbon and gas increases with increase of temperature and pressure. The minimum of 10 per cent of carbon and gas was formed at 550 deg. C. and 1 atmosphere pressure, and the maximum of 69.3 per cent at 700 deg. C and 11 atmospheres.

EXPERIMENTAL DATA

The experimental data are given in the form of tables.

Table 1—The per cent of recovered oil and the specific gravity of the recovered oil at temperatures 550 deg., 600 deg., and 700 deg. C. at 1 and 11 atmospheres pressure.

Table 2—The distillation cuts of the recovered oils.

Table 3—The comparison of the specific gravity of the distillation cuts of the recovered oil.

¹Brooks, Jour. Franklin Inst., 180, 653, 1915.

Table 4—The percentage of olefins in the distillation cuts.

Table 5—The percentages of benzene, toluene and xylene in the recovered oil.

Table 6—The percentages of benzene, toluene and xylene on basis of oil used.

Table 7—The percentages of gasoline in the recovered oils.

Table 8—The percentages of gasoline on basis of oil used and the specific gravity of the gasoline.

Table 9—The percentage of olefins in the gasoline cut.

Table 10—The effect of temperature and pressure. The percentages of olefins on basis of oil used for production.

Table 11—The percentages of the starting oil, decomposed to form carbon and gas.

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The (British) Institute of Metals

The annual autumn meeting of the Institute of Metals was to be held on Wednesday, Sept. 20, commencing at 4 p. m., in the rooms of the Chemical Society, Burlington House, Piccadilly, London. Sir George T. Beilby, F.R.S., LL.D., was to preside, and the following papers were to be presented:

The Allotropy of Silver. By W. D. Helderman.

Cadmium in Spelter. By W. R. Ingalls.

The Annealing of Arsenical Brass Containing 61 and 62.5 per cent of Copper. A Study of the Structure and Properties Developed by Varying the Rate of Cooling Within the Transformation Range. By C. H. Mathewson and E. M. Thalheimer.

The Development of the Spelter Industry. By Ernest A. Smith.

CORROSION RESEARCH STATION

The Government Research Council having made a grant of £1000 per annum toward the cost of carrying on the research inaugurated by the Institute of Metals Corrosion Committee into the causes of the corrosion of marine condenser tubes, it has been found possible by the Corrosion Research Committee, which has recently been re-constituted so as to include representatives of all bodies interested in the subject, greatly to extend their sphere of activities.

Two salaried investigators have been appointed in the persons of Capt. G. D. Bengough, D.Sc., and Dr. O. F. Hudson. They will conduct scientific researches on the committee's condenser plant now about to be installed by the courtesy of the Brighton corporation, in the Brighton Electricity Works. The plant will be worked under ordinary industrial conditions, the microscopical and other examination of the metal treated at Brighton being carried out in the metallurgical laboratories of the Imperial College of Science & Technology, South Kensington.

Electrolytic Zinc.—The Electrolytic Zinc Co., Inc., of 3 South William Street, New York, which has been successfully operating an electrolytic zinc plant at Baltimore, Md., for several months is now turning out about eight tons per day of high grade spelter running 99.92 + zinc. The raw materials used are scrap zinc and prime western spelter.

The new warehouse of the Schoellkopf Aniline & Chemical Works, Inc., Buffalo, N. Y., is expected to be ready for occupancy by Nov. 1. The plans for the building, which consists of four stories and basement, with floor area of over 150,000 sq. ft., were started just four and one-half months ago.

History of the Flotation Process of Inspiration*

By Rudolf Gahl, Ph. D.

Metallurgist in Charge of Concentrator, Inspiration Consolidated Copper Co.

The history of flotation in America is very short, at least as far as the large-scale application of the process is concerned. It is remarkable how many important developments have taken place in the last few years and are already being extensively utilized. What was new a year ago seems almost commonplace now. For this reason it is with hesitation that I follow the suggestion of Dr. Ricketts, president of the Institute, to describe the experiences of the Inspiration Consolidated Copper Company with the flotation process.

Tests Conducted in Small Test Mill

When the Inspiration company first decided to build a concentrating plant, nothing was known about flotation, and the process was to be gravity concentration pure and simple.

DEMONSTRATION TESTS CONDUCTED BY MINERALS SEPARATION COMPANY

While plans were being prepared by H. Kenyon Burch (who had been intrusted with the design and construction of the concentrator) the Minerals Separation Company, a concern at that time little known in America, asked and obtained permission to demonstrate the value of its flotation process for Inspiration ore. As a consequence, a small 50-ton flotation machine of standard design was added to the company's test plant and started to operate in the beginning of 1913. This marks the beginning of flotation at Inspiration.

The results obtained with this machine, which was operated by members of the Minerals Separation staff, so far surpassed what this company anticipated that it was decided to continue flotation tests for this purpose, two of the flotation experts of the Minerals Separation Company, I. L. Greninger and G. A. Chapman, were retained. L. R. Wallace, now superintendent of the Miami works of the International Smelting Company, was at that time metallurgist of the Inspiration company and in that capacity took an active part in these tests. Great credit is due to him for his quick recognition of the possibilities of flotation.

FLOTATION TESTS CONDUCTED BY INSPIRATION COMPANY

The tests led to the conclusion that it would be advisable to incorporate flotation into the concentrating process. Doubt existed only as to the extent to which this should be done. The first design brought out by Mr. Burch only called for flotation treatment of the concentrator tailings. While the tests were progressing, it became more and more evident, however, that flotation should form a more essential part of the milling process, and it was finally decided to leave out all the complications which are usually adopted in gravity concentration plants for the purpose of recovering as much as possible of the mineral values of the fines, and to rely on flotation alone for this purpose.

SAMPLING OF OREBODY

This decision was reached only after it had been established by numerous tests that the orebody as a whole was suited for flotation treatment. It was found, it is true, that a portion of the ore in the mine was unsuitable for flotation by the process in question, but the amount of this ore was established to be only a

*A paper presented at the Arizona meeting of the American Institute of Mining Engineers, September, 1916.

small fraction of the total. Besides, the tests proved that the ore contained in this fraction lost its refractory character when mixed with the rest of the ore.

Mr. Greninger gives the following description of the manner in which these tests were carried out:

"Sample lots, each amounting to about 10 tons and representing from 30 to 35 ft., were blasted from the back and sides of the drifts and after suitable crushing and grinding treated in the small flotation machine mentioned above."

"The results were very erratic, some showing good recovery with a high grade of concentrate, while others returned concentrate of a very low grade and also showed a low extraction."

"After a considerable number of tests had been made it was found that the good results were always obtained when treating ore of a schist gangue, while poor results resulted when the gangue was the altered and kaolinized granite which forms a part of the Joe Bush orebody."

"Ten-ton samples were taken from various parts of the mine for the purpose of determining the extent and amount of this granite ore. These lots were taken from the drifts crossing the orebody from south to north, starting in the granite ore and continuing along each drift until the schist gangue was encountered."

"In all of these tests the results were uniformly good while treating the schist ore and poor while treating the granite ore."

"Subsequently, another series was inaugurated with the view of determining the amount of granite ore that could be mixed with the schist ore without interfering with the treatment of this mixed ore by flotation."

"Various percentages of granite ore were mixed with clean schist and the mixture treated by flotation. It was found that 10 per cent of granite caused no change in the behavior of the ore in the flotation plant, and when 20 per cent of the granite was mixed with the schist ore only a slight difference was noted, this difference consisting in a slight lowering of the grade of the concentrate with a corresponding falling off in extraction."

The conditions described by Mr. Greninger are well illustrated by a drawing made by C. E. Arnold of the

mine engineering staff of the company, which represents laboratory flotation results on samples taken from a drift in the Joe Bush orebody (Fig. 1). The results show clearly that the granite by itself does not interfere with flotation, but only the fault material, evidently corresponding to what Mr. Greninger terms kaolinized granite.

OTHER RESULTS OBTAINED IN SMALL TEST MILL

The test conducted in the small test plant established in a general way the physical conditions under which Inspiration ores could be treated advantageously; for instance, it was decided that raising the temperature did not improve the results obtained in proportion to the extra expense of such procedure.

As far as flotation oils are concerned, those in charge of the tests came to the conclusion that cresylic acid (98 per cent pure) should be used as the main flotation agent, and should be supplemented by crude turpentine. As the most important result brought out by these tests, I consider the discovery that the flotation agents may profitably be added in the grinding machines, while it had formerly been the customary practice to add the "oils" in agitating tanks especially provided for the purpose. This discovery had an important bearing on the later developments in the Inspiration milling practice, inasmuch as it paved the way for the use of much heavier oils; for instance, coal tar, which it is impossible to amalgamate thoroughly with the pulp in agitating tanks. Mr. Chapman, I think, made this important discovery during this period (U. S. Patent 1,102,874).

The details of the flow sheet to be followed were left to be decided by tests on a larger scale. Only this much was settled: That no concentration of any kind, either flotation or gravity, should be attempted before the ore was reduced to the fineness required for the flotation process. This decision was brought about by the fact that excellent recoveries were obtained when this procedure was followed, and was, of course, also strongly urged by considerations of simplicity in the milling process and cheapness of milling operations.

In these tests a 50-ton flotation machine of Minerals

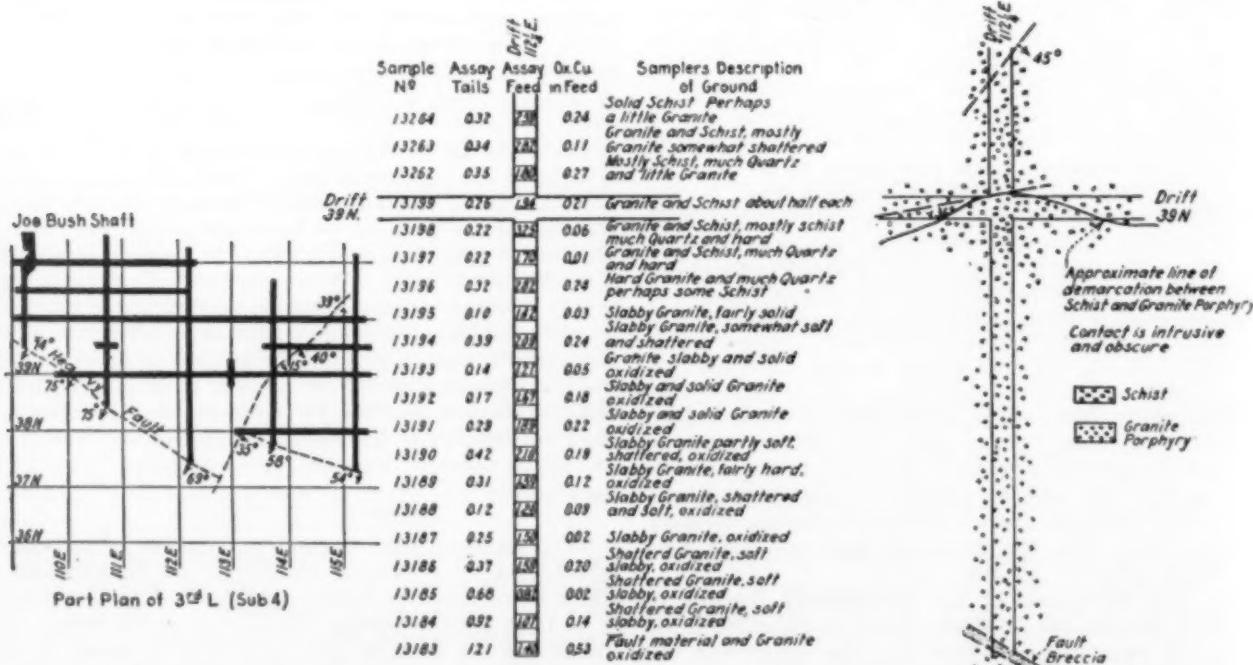


FIG. 1—MAP SHOWING GEOLOGY AND RESULTS FROM LABORATORY FLOTATION TESTS ON 5-FT. SAMPLES TAKEN AT 10-FT. INTERVALS ALONG DRIFT BETWEEN 37.40 AND 39.35 N.

Separation Company Standard type was used. In the general design, it was similar to the larger machine later put in use. It had eight agitating compartments with propellers of 12-in. diameter revolving with a peripheral speed of from 1200 to 1400 ft. per minute.

Tests in Large Test Mill

FLOW SHEET

In order to test on a large scale the points already settled in the small test mill, and to decide the points left undecided by the small-scale experiments, a 600-ton test plant was built and put into operation at the beginning of January, 1914. It was my privilege to conduct those tests in co-operation with Mr. Greninger, who represented the Minerals Separation Company, and with the representatives of other concerns, who in the course of time decided to submit flotation machines to the consideration of the Inspiration company. The flow sheet of this 600-ton test mill was extremely simple. It is illustrated in Fig. 2.

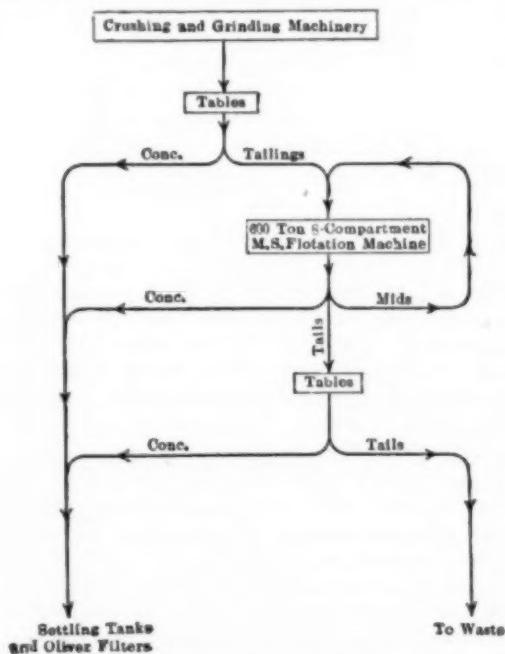


FIG. 2—FIRST FLOW SHEET OF 600-TON TEST MILL,
INSPIRATION CONSOLIDATED

The ore after being crushed to the desired fineness by machinery, which was tested out at the same time, was sent to tables; from these the concentrates went to the concentrate bins, while the tailings passed on to an eight-compartment flotation machine of the Standard Minerals Separation type with 24-in. stirrers. Later a twelve-compartment machine of the same type was added and operated in parallel with the eight-compartment machine. The tailings from the flotation machines were passed on to other tables, the concentrates from which, combined with the concentrates from the upper tables and the flotation machine, went to the concentrate bins, while the tailings went to waste. The flotation machine was operated in the standard manner, the feed being introduced into the first agitating compartment, passed to the first spitzkasten, drawn to the second agitating compartment, sent from there to the second spitzkasten and drawn to the third agitating compartment, etc., the agitators forming the necessary suction for the transportation of the pulp from the spitzkastens to the following agitating compartments. A final concentrate was made from one or more spitzkastens, while the concentrate from those remaining was

considered a middlings product and was returned to the head of the machine for retreatment.

This flow sheet was extremely simple, but after awhile even this was considered too complicated, inasmuch as the necessity of table treatment ahead of flotation treatment was doubted.

DISCUSSION OF THE VALUE OF PRELIMINARY TABLE TREATMENT

The advantages pointed out in favor of the preliminary table treatment were about as follows: Since the tables would make a certain recovery, an impoverished flotation feed would result and assist the flotation machine to make a tailings product low in copper. However, the validity of this argument was doubted for the following reasons:

In the first place, if complications are to be avoided, the preliminary table treatment has to be of a comparatively rough character; the refinements of hydraulic classification have to be dispensed with, as by its use more water would be introduced into the pulp than would be advisable for the following flotation process. It must be taken into consideration that the pulp delivered to the tables already contains about 3 tons of water to 1 ton of solid matter, experience having shown that the grinding machines, consisting of either ball or pebble mills, deliver a product of the desired fineness, about 1 or 2 per cent on 48-mesh, when the consistency of the overflow from drag-belt classifiers, working in conjunction with the grinding mills was carried at about this figure; experience also showed that this consistency is suitable for the flotation treatment, while greater dilution of the pulp resulted in an increased copper loss. The logical way out of this difficulty would be to introduce settling tanks, for which, however, the modern mill designer has a just abhorrence; at least, when they are to be placed in the middle of the mill. Neither the liberal use of dressing water nor a low tonnage rate would be permissible for the same reason. On this account, a high recovery could not be expected from a preliminary table treatment. During our tests it averaged around 33 per cent.

Furthermore, the assumed fact, that an impoverished feed results in a better recovery of the flotation machine was strongly doubted by some of the flotation experts, who claimed that in order to form a froth which had the necessary carrying power for mineral it would be better to leave as much mineral as possible in the feed to the flotation machine. In other words, their advice was to leave out the tables in order to permit the flotation machines to do more efficient work.

There is no doubt, however, that tables will catch a certain amount of mineral (especially coarser grains) which will escape in the flotation process. For this reason, tables have to be used to insure the highest recovery,¹ but it seems that tables following the flotation treatment would make up for this deficiency of the flotation machine better than tables ahead, inasmuch as they would not work under the disadvantage, known to every millman, of receiving too rich a feed. It is well known that it is possible to make a much lower table tailing working on feed containing a small percentage of copper than on a feed rich in copper. From theoretical speculations, therefore, no valid reason was advanced that increased recovery should result from table treatment ahead of the flotation treatment.

The next argument advanced by the supporters of a preliminary table treatment was, that it would result in an improvement of the grade of the general concentrates, inasmuch as it would be possible to make a

¹This applies only to the flow sheet under discussion.

very clean product on the tables, thereby raising the general average of the concentrates. There is evidently some sound foundation for this point; how much, could not well be investigated without resorting to actual experiments.

A third point seemingly in favor of preliminary table treatment is this: Flotation concentrates offer more or less difficulty in mechanical handling; vacuum or pressure filters have to be resorted to for this purpose. It was pointed out, therefore, that if a certain percentage of the total concentrate could be saved on the tables, and a table concentrate produced containing only a small amount of the slime, so troublesome in filter treatment, it might be a decided advantage; the quantity of concentrate to be handled on filters might be materially reduced and economies effected in this manner. At the same time, experience shows that the flotation concentrate resulting under those conditions, because it contains less of the coarser sand, is more difficult for the filters to handle than it would be were the sand left in. Very likely, therefore, no decided improvement in the handling of the concentrates would

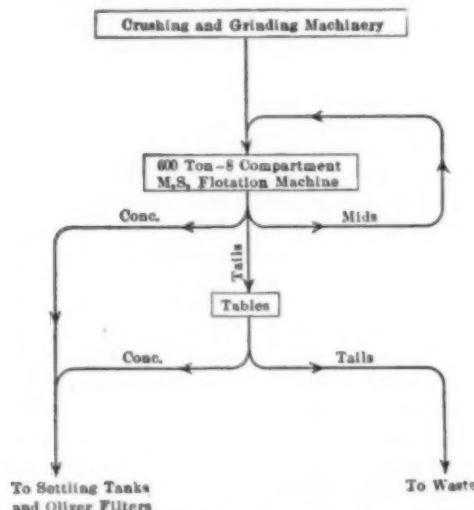


FIG. 3—SECOND FLOW SHEET OF 600-TON TEST MILL,
INSPIRATION CONSOLIDATED

result from the separation of the table concentrates from the flotation concentrates, at least under the conditions prevailing here.

The same objections do not hold true for tables when used after the flotation process, as in that case no limitations are imposed regarding the hydraulic and dressing water, and the tables cannot help but make an additional small recovery of concentrate. On account of the fact that the table feed is necessarily low in copper, the tailings will be correspondingly low. In all cases, therefore, where flotation treatment does not make a full recovery, or practically so, of mineral values, tabling after flotation seems imperative.²

Although such theoretical considerations were indulged in, no decision was based on them. To settle the main points in question, a series of tests was carried out. On alternate days, the "upper" tables were bypassed (Fig. 3) while on the remaining days, they were utilized.

Table 1 gives the résumé, on the strength of which it was decided to use secondary tables only and to leave the preliminary table treatment (ahead of the flotation treatment) out of the flow sheet to be adopted in the concentrator under construction. That this conclusion is justified seems to be borne out by the foregoing facts.

²This remark again refers only to the flow sheet under discussion.

In January and February, 1914, the lower table floor was not in operation. For this reason, the flotation tailings were not treated on tables. There was, however, table treatment ahead of flotation, the following results being obtained: Table recovery, 39.42 per cent; flotation recovery, 33.35 per cent; total recovery, 72.77 per cent. From March to August, 1914, various flow sheets were tried; tables were sometimes used pre-

TABLE I—COMPARISON OF EFFICIENCY OF FLOW SHEET NO. 1 (FIG. 2) AND FLOW SHEET NO. 2 (FIG. 3)

Description	FLOW SHEET	
	No. 2	No. 1
Assay of mill feed	1.72	1.67
Assay of flotation machine feed	1.72	1.32
Assay of flotation machine tails	0.46	0.43
Assay of lower table tails	0.29	0.30
Assay of general concentrates	32.71	31.72
Recovery upper tables + flotation machine		75.30
Recovery flotation machine	74.30	
Additional recovery on lower tables	9.40	7.40
Total recovery	83.70	82.70
Tonnage per deck on lower tables	25.70	23.20
Tonnage per deck on upper tables		87.00
Oil consumption, cresol + turpentine in pounds per ton	0.95	0.82

REMARKS.—The recoveries are calculated from the feed and tailings assays and the assay of general concentrates.

CONCLUSIONS.—Roughing on upper tables reduces the tailings assay of the flotation machine slightly, while it does not seem to affect the assay of the lower tables appreciably. Increased recovery results from the use of the lower tables.

ceding and sometimes following flotation, and sometimes in both places. The figures on recovery are, for this reason, not comparable with the preceding ones. From September to December, 1914, no tables were used preceding flotation; the flotation tailings were, however, treated on tables. The results obtained were: Flotation recovery, 70.83 per cent; table recovery, 7.51 per cent; total recovery, 78.34 per cent.

CALLOW FLOTATION INSTALLATION

While the test mill was in operation, Mr. Callow, president of the General Engineering Company, advised the Inspiration company that he had invented and perfected a new flotation process which, in his opinion, would give as good, if not better, results than the machine of the Minerals Separation Company. As a consequence, arrangements were made to add a unit of machines of the Callow type. The flow sheet using Callow cells is illustrated in Figs. 4 and 7. It consisted of four rougher flotation cells, which served for

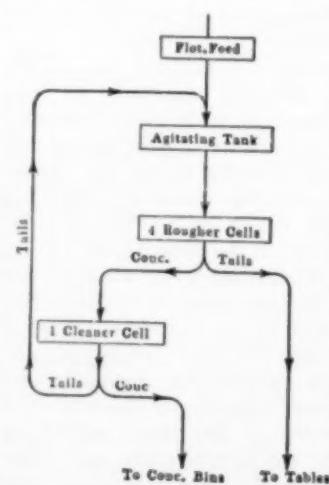


FIG. 4—FLOW SHEET OF EXPERIMENTAL CALLOW FLOTATION PLANT

the production of a low-grade concentrate, and another cell of the same construction which was supplied for the purpose of cleaning the concentrates made on the rougher cells. The tailings resulting from the cleaner cells were returned and mixed with the pulp entering the rougher cells. With the machine was furnished a Pachuca tank for the purpose of mixing flotation oil into the pulp entering the plant, should it be more desirable to do this in addition to or in place of feeding the oil to the grinding machines, as had proven useful both in the

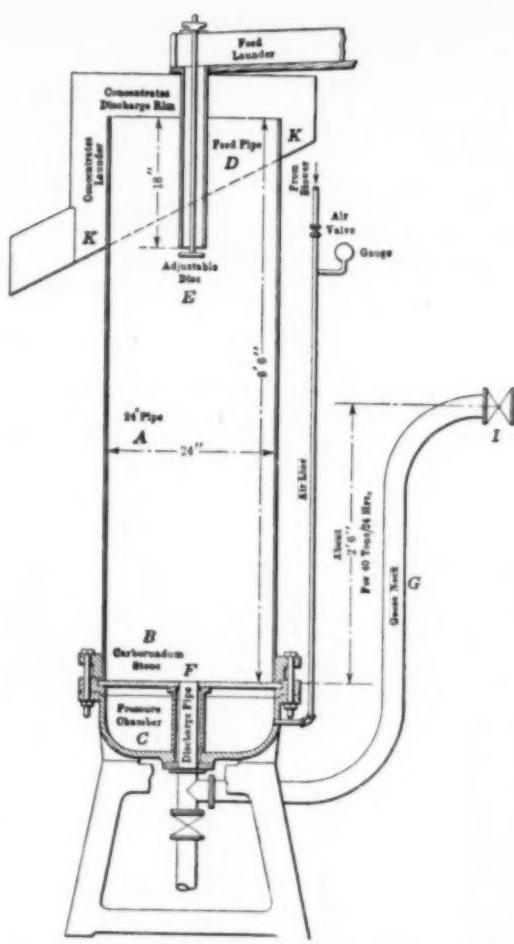


FIG. 5—FLINN-TOWNE FLOTATION MACHINE

small and in the larger test plants. As a matter of fact, the use of the Pachuca tank was abandoned after several months' operation.

The Callow cells work on a different mechanical principle from that underlying the Minerals Separation Standard machine, inasmuch as no movable parts are used for the purpose of producing the fine dissemination of air with the pulp, which seems to be essential for any kind of flotation machine; while the Standard Minerals Separation machine depends on the operation of fast-revolving impellers, the dissemination is effected in the Callow machine by blowing air through the pores of a porous blanket, which forms the bottom of each cell.

The Callow machine, illustrated in another paper is ingeniously simple. The feed enters at the upper end of the inclined bottom, while the tailings are discharged through the float valve at the lower end, the concentrates overflowing at the top of the flotation tanks. The porous bottom of the cell is set on an incline to make possible the treatment of feed containing coarse sand. The movement of such sand particles from the feed to the discharge end is thereby accelerated.

The mechanical principle of aeration and agitation by the admission of air through a porous medium, which has been termed "pneumatic flotation," was undoubtedly discovered by Mr. Callow⁴ and his associates independently of other inventors, although an earlier patent had been taken out for the same thing in Eng-

land by Minerals Separation (British Patent, 10,929, May 3, 1910) and long before the installation of the Callow machine at this mill, Inspiration ore had been tested in New York by a pneumatic flotation machine constructed jointly by Messrs. Flinn and Towne.⁵ The results of this test were so good that a small test plant of this system was installed at Inspiration.

FLINN-TOWNE INSTALLATION

The Flinn-Towne machine, as mentioned, utilizes the pneumatic principle also but the application is somewhat different. An illustration of a single Flinn-Towne machine is given in Fig. 5, while Fig. 6 shows the outline of the installation. The cells are constructed in the shape of cylindrical tanks, the bottoms of which are formed by the porous medium. The feed enters near the top in the center of the cylinder, while the tailings leave the machine through a center hole in the porous medium. In the Flinn-Towne installation, only one roughing machine was provided, while additional cells served for the purpose of cleaning both rougher tailings and rougher concentrates. The tailings produced by the concentrate cleaner cell were returned to the head of the roughing cell. In place of the canvas blanket of the Callow machine, Messrs. Flinn and Towne in the demonstration test at Inspiration used carborundum stones as the porous medium through which the air is injected into the pulp.

COLE-BERGMAN INSTALLATION

The Flinn-Towne machine was withdrawn from the contest after a competitive test between this machine and others had run for several months, although the results obtained looked very encouraging. Its place

⁴Mr. Callow refers to his installation at the National Mill, Mulian, Idaho, April, 1914, as the first successful commercial plant utilizing the pneumatic principle.

⁵This test was made in the presence of Dr. L. D. Ricketts, consulting engineer, and W. D. Thornton, vice-president of the Inspiration company. According to F. B. Flinn, a 600-ton plant of the Flinn-Towne flotation system was shipped to the Tezuitlan Copper Co. in Mexico in the Spring of 1913. This could not be put into operation on account of the political conditions prevailing then. Otherwise, this would have been the first commercial pneumatic flotation plant.

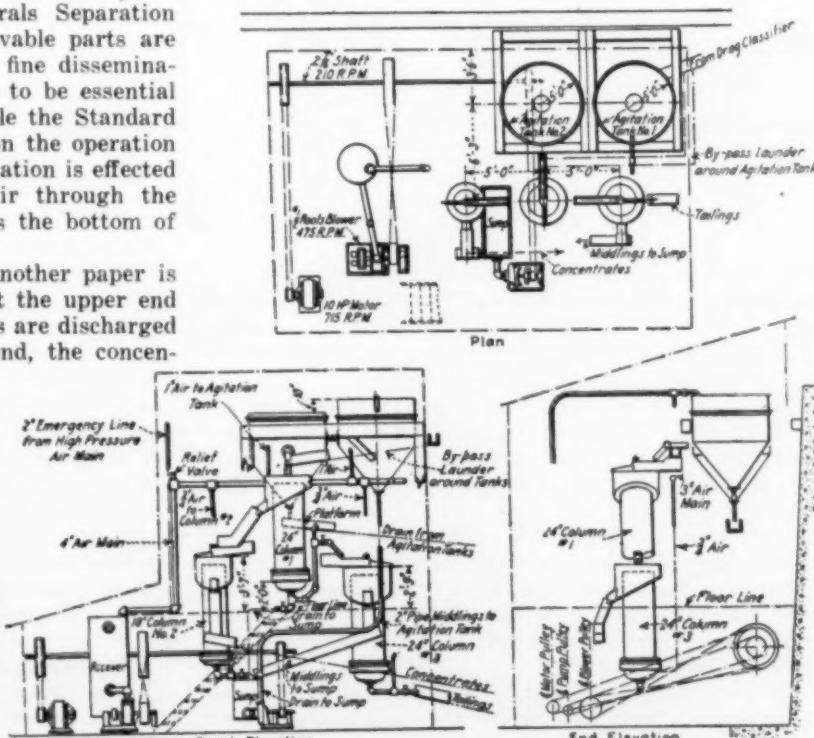


FIG. 6—OUTLINE OF FLINN-TOWNE FLOTATION INSTALLATION

was taken by a flotation machine designed by Messrs. Cole and Bergman.

Their machine is illustrated in Fig. 7. In principle the cells are similar to those of the Flinn-Towne machine. Evidently, the designers tried to improve on this system by mechanically developing the idea underlying the machine, and by changing one point, which in their opinion formed a weak part of the Flinn-Towne machine. This is the construction of the porous diaphragm, which, as explained below, was formed by a round carborundum disk.

While carrying on the test of the Flinn-Towne machine, it proved necessary occasionally to wash the carborundum stones by injecting a water pipe from the top and even by removing the stones and cleaning them with water, acids, etc. Messrs. Cole and Bergman ascribed this deficiency to the fact that on account of

for the purpose of cleaning the concentrates produced on the larger machine.

METHODS FOLLOWED IN COMPETITIVE TESTS

In the interest of a fair contest between the flotation machines of the different types, each machine was provided, as nearly as possible, with the same character of pulp as the rest. In the beginning this was accomplished by providing each machine with one or more pebble mills to which feed was sent in such quantities that a mill product of practically the same fineness resulted in each case.

When the results of the competitive tests began to approach each other very closely, the equalization of the pulp furnished to the different machines was still improved upon by mixing the ground product discharged from all the mills, and sending it to a divider

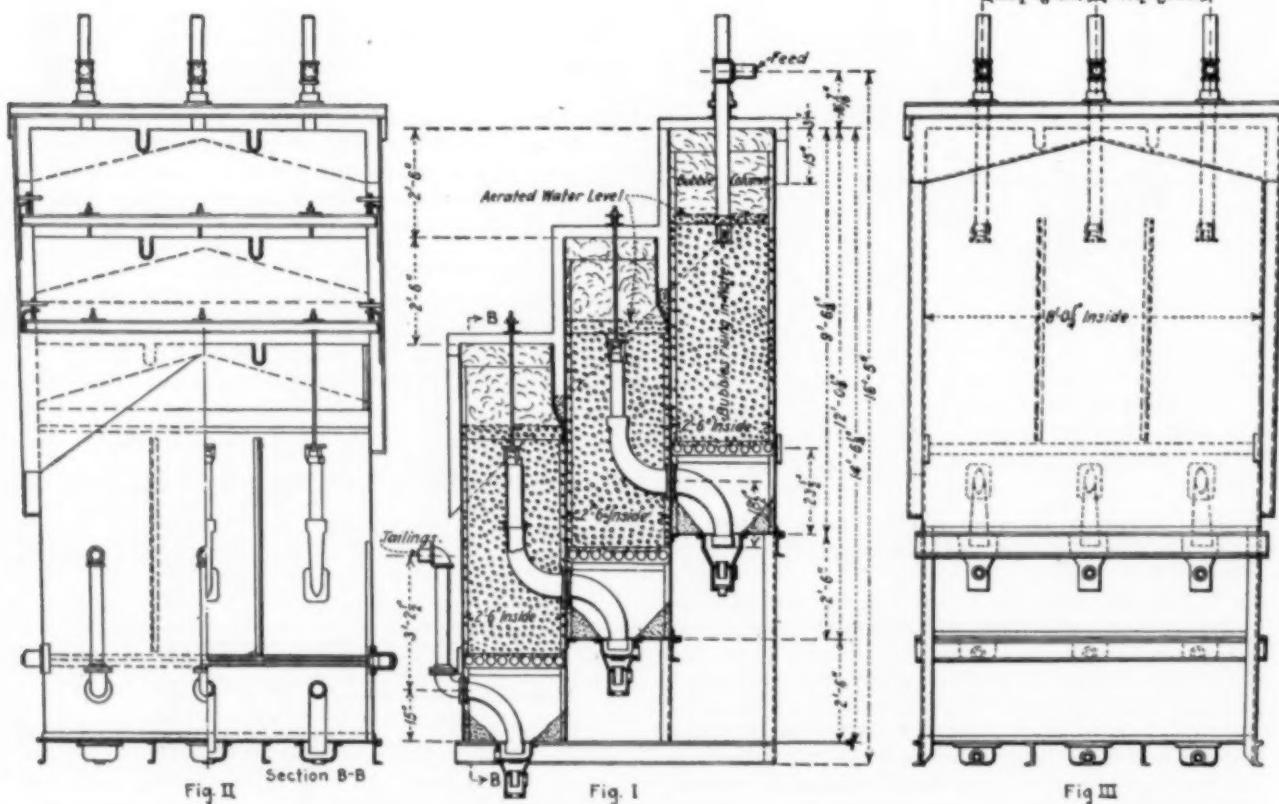


FIG. 7—COLE-BERGMAN FROTHING CLASSIFIER

the horizontal position of the porous medium, sand had a tendency to lodge thereon and to impede or prevent the passage of air through the pores. They substituted, therefore, a system of perforated tubes covered with a suitable fabric, such as canvas or flannel.

This led to the construction of a porous medium in the form of a grate, as shown in the illustrations. Their idea seems to be a very happy one, as it makes it possible to apply the flotation process to ore pulps containing comparatively coarse particles of sand; for instance, it seems possible to treat with this machine ore mixtures that contain sand particles as coarse as ten-mesh and perhaps even coarser. Using this machine, the millman is now in a position to treat slime by flotation without the necessity of removing it from admixture with sand.

The Cole-Bergman machine has given good results in our tests as have the rest of the machines utilizing the pneumatic principle. It was operated in conjunction with a smaller machine of the same type installed

which permitted the division into as many parts as there were competing machines, and in any proportion desired.

As it had been decided in former experiments not to install tables ahead of the flotation process, no preliminary table treatment was used during the competitive tests, but each flotation system was furnished with a set of tables for the retreatment of the flotation tailings.

It developed that this was essential in trying to arrive at a fair valuation of the machines, as some of the machines produced tailings from which additional mineral could be extracted by the table treatment more easily than from the tailings of other flotation machines, the cause evidently being that flotation machines of one type have a tendency to save more of the finer particles, while flotation machines of another type permit of a better recovery of coarser grains.

Those flotation machines that make a good recovery on the sand, but leave a larger percentage of mineral

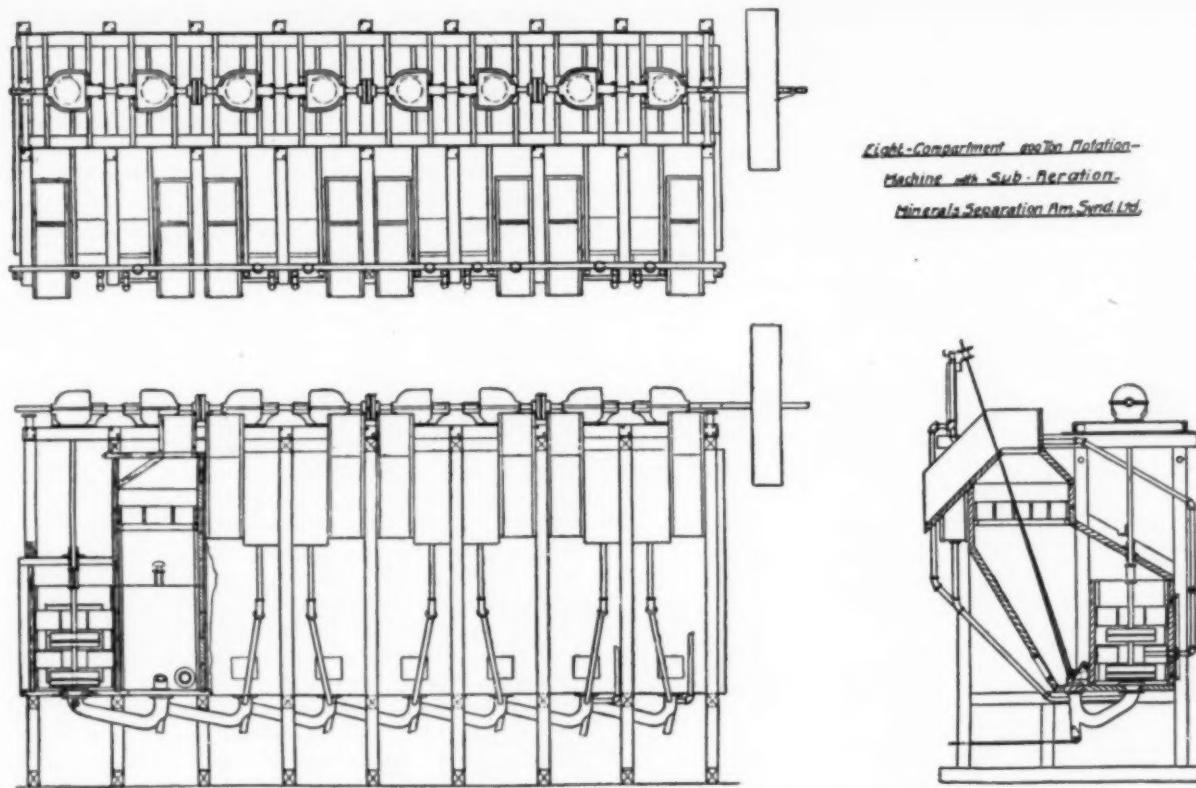


FIG. 8—MINERALS SEPARATION SUB-AERATION TYPE OF FLOTATION MACHINE

in the slime, will not benefit from a subsequent table treatment as much as those of the other kind.

ADVANTAGE OF PNEUMATIC FLOTATION MACHINES

In the course of the tests at Inspiration, the fact became apparent that, by the application of the pneumatic principle, a higher recovery of the slime is made possible than without the utilization of injected air, although the Standard Minerals Separation machine also gives excellent results when the tonnage is reduced to a considerably lower figure than the machine is supposed to be able to treat economically.

Therefore, in cases where high power consumption is of little importance, the Standard Minerals Separation machine will fill the requirements of a flotation machine remarkably well. When, however, the power consumed has to be seriously considered, it seems advantageous in the light of the Inspiration experiments to make use of pneumatic flotation for the reason pointed out above, i.e., that poor work of flotation machines on sands can be made up by a subsequent table treatment, while poor work on slime cannot. Within certain limits, it is more important to insist on machines effecting a good slime recovery than on machines making a good sand recovery.

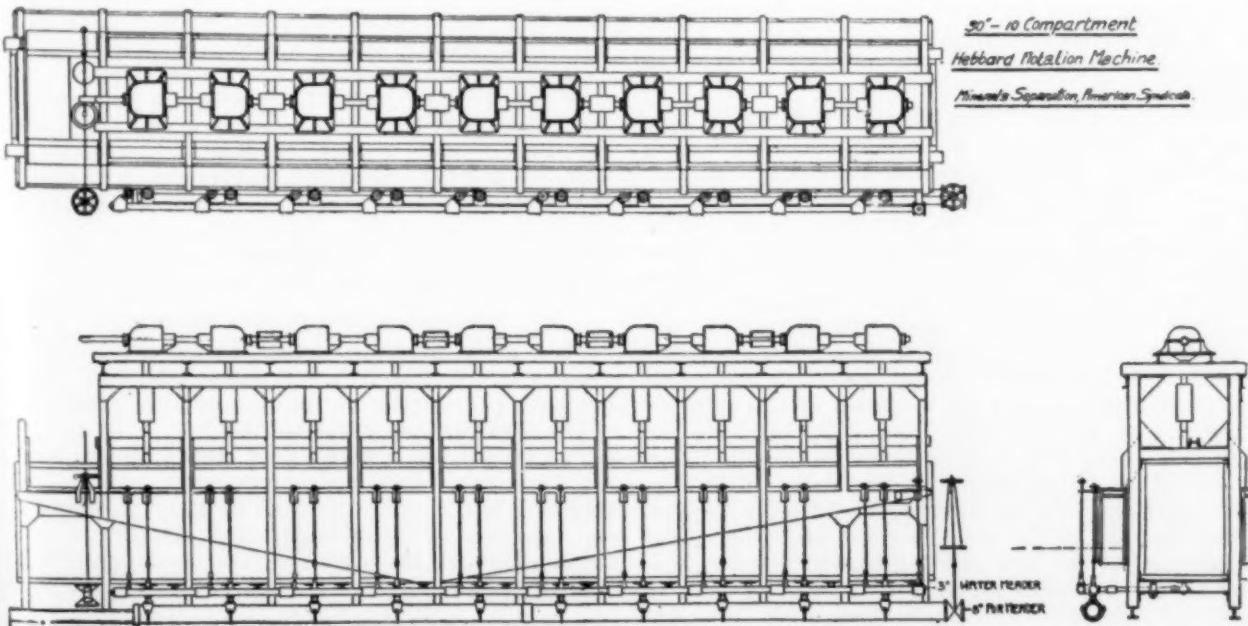


FIG. 9—HEBBARD TYPE OF MINERALS SEPARATION MACHINE

PNEUMATIC MACHINES OF MINERALS SEPARATION
COMPANY

The Minerals Separation Company, realizing this, offered to put in their subaeration type of machine which added the advantages resulting from the use of injected air to the advantages which their Standard machines seemed to have in saving coarser mineral. This resulted in the construction and testing successively of two of their subaeration type machines, one in which the old spitzkastens still were retained, and another one in which they were dispensed with. As seen from the illustration (Fig. 8) provisions were made in the former machine to admit air to the pulp conduits carrying the pulp from the spitzkastens to the agitating compartments next in succession, in order to make this air available to lift mineral to the top of the spitzkastens where it can be skimmed off. The agitating compartments are closed at the top by covers set

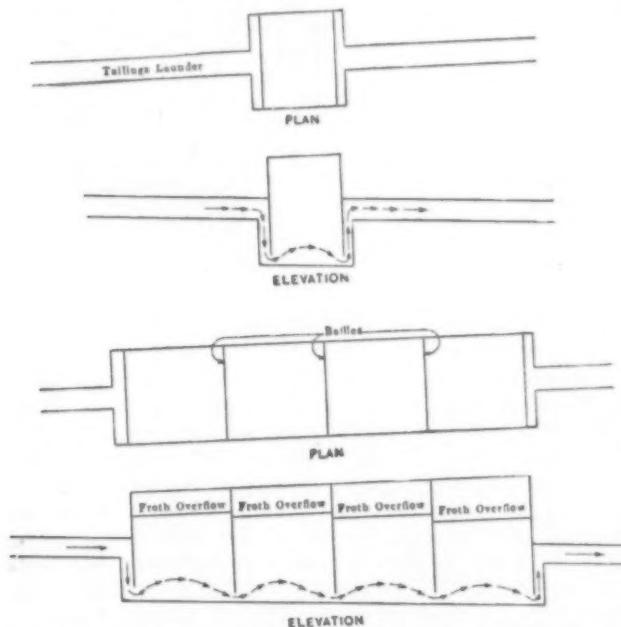


FIG. 10—DIAGRAM SHOWING ORIGIN AND DEVELOPMENT OF INSPIRATION FLOTATION MACHINE

on an incline in such a way that the air rises to the top in the agitating compartments and is conducted to the spitzkasten, being thereby utilized for the purpose of carrying the mineral values.

This construction of the Minerals Separation Company was, however, only an intermediate step toward the design of the second-named machine, a machine of greater simplicity, which is similar in principle to the one illustrated in Fig. 9. The machine consists of a long rectangular tank without any partitions, in which a number of agitators revolve, while air is injected underneath each impeller. We call the machine the "Hebbard Type" Minerals Separation Machine.

In order to limit the agitation to the lower part of the machine and to provide an area of comparative quietness in the upper part, a system of baffles is arranged above the agitators. As a consequence, the froth is given a chance to separate out in the upper portion of the rectangular tank, and flows off on both sides lengthwise into launders provided for the purpose.

This machine marks an important progress in the development of the Minerals Separation flotation systems toward increased recovery of copper, at least as far as the Inspiration ores are concerned. In our tests it effected a higher recovery of the fine mineral particles than the old machine had accomplished. The

machine also has the advantage of greater simplicity and relatively low power consumption. The only drawback that we have found in the operation of the machine, extending over a number of months, is that the agitating shafts, which are suspended from above, have a tendency to bend and, if not straightened, soon cause the impeller blades to strike against the baffles, breaking one or the other.²

FLOAT SKIMMING DEVICE

While the competitive tests of the different flotation machines were being conducted, it was observed that large quantities of mineral froth frequently appeared in the tailings launders. The idea suggested itself to remove the froth, thus increasing the recovery obtained in the flotation machines and concentrating tables by an additional small amount. After some experimenting, a way was found in which this could be easily accomplished. The tailings launder was widened and deepened for some distance. The tailings stream was forced to pass underneath a baffle on entering the widened space, and was also forced to travel under another baffle board at the end of the space, thus being made to rise through the restricted area formed by the tailings end baffle and the back-wall of the float-saving device, which is illustrated in Fig. 10.

Contrary to what might be expected, tailings sand of the fineness of Inspiration tailings will not lodge in the widened-out space unless the length is greater than a certain critical distance, nor will it choke the upward channel in the tailings end of the machine. When conditions demanded the construction of the float-saving device in greater length, it was found that the accumulation of sand, which has a tendency to form in the middle of the machine, can be avoided by arranging an additional baffle not reaching quite to the bottom in the center of the machine. If the machine is built longer yet, more than one intermediate baffle is necessary. The explanation for this behavior of the pulp, which at first glance might seem paradoxical, is that, on account of reduced passageway between the lower part of the baffles and the bottom of the machine, the pulp is forced to travel through at speed so high that it will not permit the settling out of sand. As a consequence, a hydrostatic head will establish itself between front and back of such a baffle and has to be taken care of in the design. It is found, however, in actual practice, that the hydrostatic head required to keep the sand from settling out by creating an accelerated current underneath the baffle is relatively small.

A similar consideration explains the fact that the upward tailings passage at the end of the machine has very little, if any, tendency to choke; to take care, however, of possible choke-ups that might be caused by the discharge of coarse rocks, pieces of wood, etc., into the pulp, it was found advisable to arrange some air jets in the bottom of the upward tailings passage to assist in clearing it whenever necessary.

INSPIRATION FLOTATION MACHINE

This device was in actual operation for several months at our test mill and made itself pay well by adding 1 per cent to the recovery actually obtained.

The question then presented itself as to whether this device, which was successful in saving mineral escaping from the flotation machines, could not be transformed into a flotation machine itself by arranging for the injection of finely distributed air into the pulp passing through the machine. The development of the idea led to what we call our Experimental Inspiration

²This trouble is alleviated in the Hebbard machines turned out more recently by the Minerals Separation Co. by the provision of suitable bearings for the impeller shafts in the bottoms of the machines.

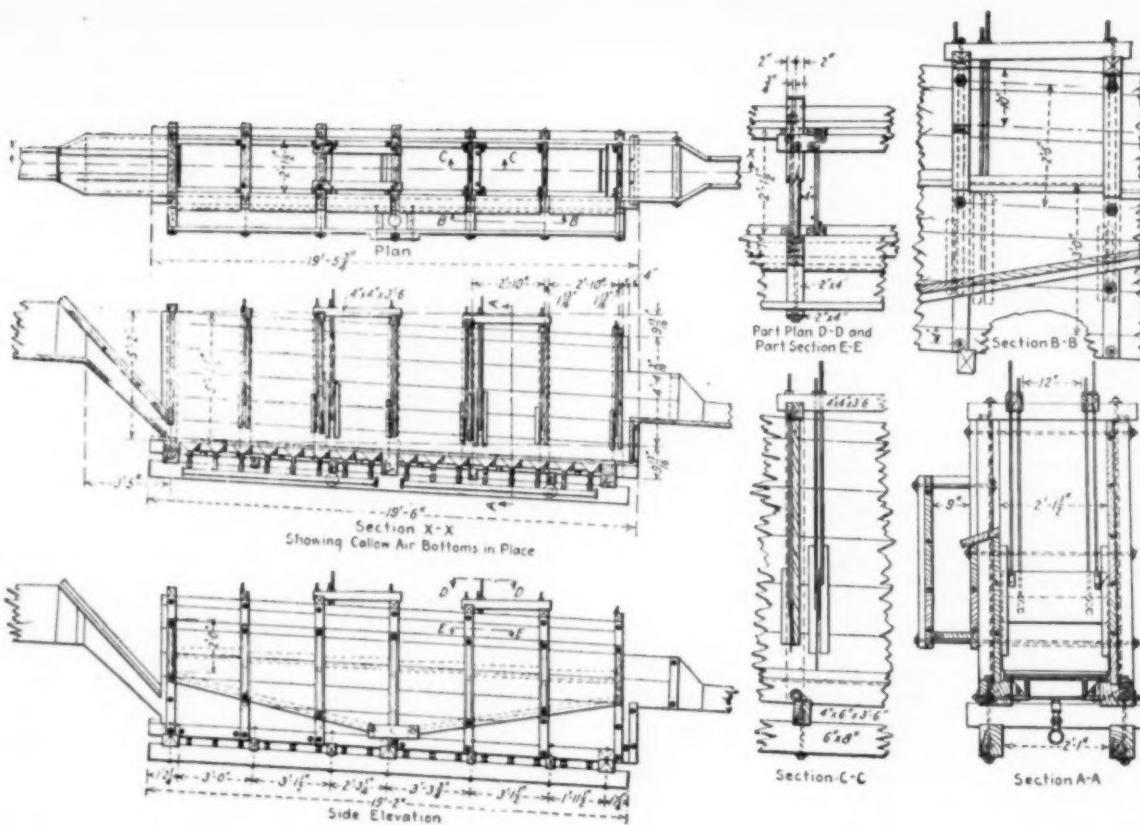


FIG. 11—EXPERIMENTAL INSPIRATION FLOTATION MACHINE

Flotation Machine, which was built on a small scale, that is of a size to treat up to 100 tons in 24 hr., and was placed in competition with the other flotation machines already in existence. This machine is illustrated in Fig. 11.

The air was injected through a porous bottom arranged in a way similar to the bottoms of the Callow and Flinn-Towne machines (as a matter of fact, a Callow bottom was used in the first tests) and the concentrate flowed over the edge on one side of the flotation tank.

The mode of operation followed was also similar to the one developed for the other air machines. A low-

grade concentrate was produced and retreated on a similar machine of the same construction, called the cleaner machine, the tailings from which were returned to the head of the roughing flotation machine.

As will be seen from the drawing, the construction of this machine is extremely simple and comes pretty near to an ideal of Mr. Mills, our general manager, who prophesied that the flotation machine of the future would be nothing but a launder with provisions for injection of air. The method of effecting the concentration in two stages was also followed when the new types of the Minerals Separation machines were put into commission.

ARRANGEMENT OF CALLOW CELLS IN SERIES

In principle, the Inspiration machine shows one difference from the Callow machine; viz., that instead of splitting the pulp between a great number of machines, it is forced to travel through a series of compartments in succession. This is the same policy that had also been followed in the construction of the Minerals Separation machines. The question then came up, whether it might not be of advantage to arrange the Callow cells also in series. To test out the idea, the flow sheet of the Callow plant was changed (see Fig. 12). The primary feed was sent to two of the cells, the other cells receiving the tailings from these primary cells.

This arrangement showed at least no disadvantage over the multiple treatment; it seemed superior to the other system in the one respect that it showed at a glance whether the cells were operated well, because in that case most of the concentrate would be produced on the primary cells while the secondary cells would produce a rather light-colored froth and would add only a small fraction to the recovery made on the primary cells. Both primary and secondary concentrates were treated jointly in a cleaner cell, while the tailings from

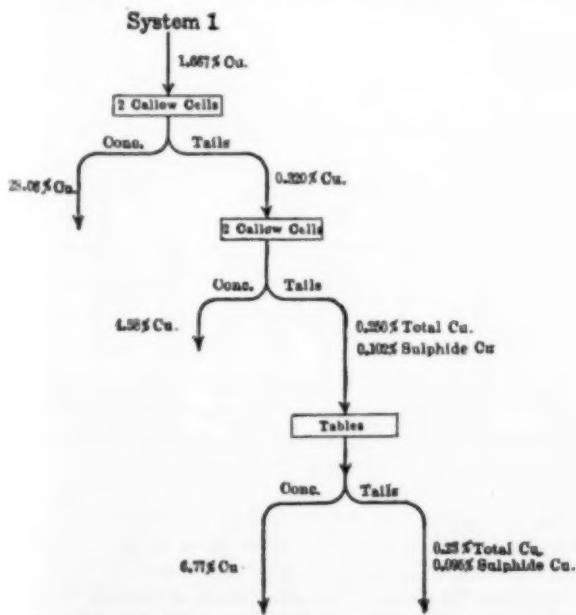


FIG. 12—TESTS WITH CALLOW CELLS IN SERIES

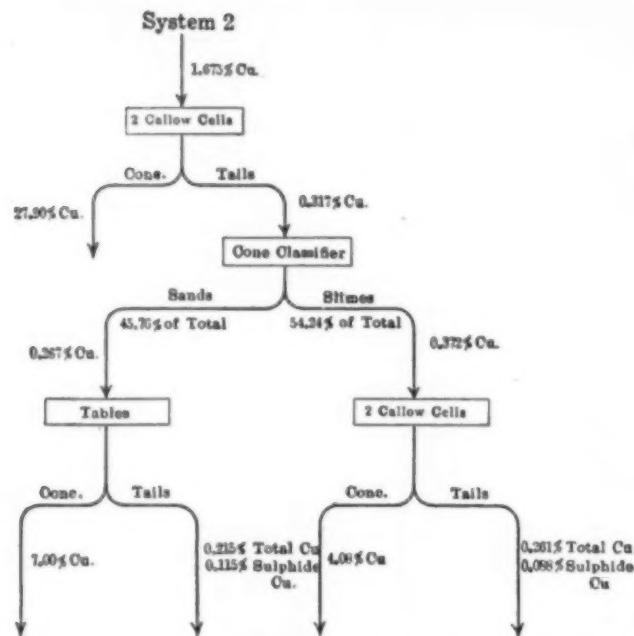


FIG. 13—TESTS WITH CALLOW CELLS IN SERIES, WITH CLASSIFIERS BETWEEN

the secondary cells were conveyed to a number of concentrating tables for retreatment.

A variation of the latter flow sheet was also tested (compare Fig. 13). Between the primary and secondary cells, a cone classifier was interposed for the purpose of making a separation between the sand and slime. The slime was sent to the secondary flotation machines, while the sand was passed to tables. This latter flow sheet was finally decided upon for the Callow installation in the large concentrator. Tests made with the object of establishing which of the two is superior, resulted in a tie. Some of the figures on this point are given in Table II.

is wise to send the cleaner tailings back to the head of the rougher machine for retreatment. In the limited time at our disposal, it proved impossible to substitute something better, but the chances are that the same holds true of flotation that is true for water concentration; viz., that middlings are sent back for retreatment mainly because the designer does not know anything better to do with them. In principle it seems wrong to follow this practice, because when heavy copper losses occur in concentrating machines which express themselves in high tailings, there is always a doubt as to whether this is due to poor recovery made in the primary treatment or to heavy losses incurred by middlings sent back for retreatment.

COAL TAR AS FLOTATION AGENT

It was to be expected when the flotation process was installed in our test plant, that there would be ups and downs in the recovery because the process was rather new, especially in its application to chalcocite ores. For the month of June, 1914, the recovery obtained in the test mill showed a sudden drop, and the serious problem confronted us of establishing the cause and finding a remedy. Some of the flotation experts suggested that it might be due to the fact that a new shipment of cresylic acid which had been received and used, at that time might not fill the specifications of being 98 per cent pure. We did not feel competent to say whether the impurities actually amounted to more than 2 per cent. We were, however, inclined to think that perhaps cresylic acid, which is, as is well known, one of the products resulting from fractional distillation of coal tar, might not represent the fraction most suitable for the flotation of our ores. Having no coal tar available in the neighborhood, we proceeded to make some by distilling a sample of ordinary New Mexico soft coal and separating the tar thus formed into the fractions distilling off at different temperatures.

Our facilities for testing oils were limited at that time. The Minerals Separation Company's represent-

TABLE II—RETREATMENT OF TAILINGS FROM TWO CALLOW CELLS. SCREEN ANALYSIS OF FEED AND TAILS OF SECONDARY CALLOW CELLS

Mesh	SYSTEM 1								SYSTEM 2								
	FEED				TAILS				FEED				TAILS				
	Per Cent Weight		Per Cent Cu	Cu Contents	Per Cent Weight		Per Cent Cu	Cu Contents	Per Cent Sol. Cu	Per Cent Weight		Per Cent Cu	Cu Contents	Per Cent Weight		Per Cent Cu	Cu Contents
	Cum.	Indiv.			Cum.	Indiv.				Cum.	Indiv.			Cum.	Indiv.		
65	5.0	5.0	0.29	0.014	5.0	5.0	0.21	0.011	0.05	.....	.....	.....	.....	4.0	4.0	0.17	0.007
100	19.0	14.0	0.25	0.035	19.2	14.2	0.15	0.021	0.06	3.8	3.8	0.20	0.007	10.8	6.8	0.14	0.010
150	32.2	13.2	0.29	0.039	32.4	13.2	0.16	0.021	0.10	10.6	6.8	0.25	0.017	19.0	8.2	0.25	0.021
200	42.4	10.2	0.33	0.034	42.8	10.4	0.21	0.022	0.11	18.6	8.0	0.30	0.024	100.0	81.4	0.326	0.242
	100.0	57.6	0.35	0.201	100.0	57.2	0.27	0.155	0.20	100.0	81.4	0.40	0.374	.....	.....	0.28	0.280
Assay calc.	0.32	0.323	.....	.....	0.23	0.230	0.15	.....	.....	0.370	.....	.....	.....	0.26	0.26	.....	.....
Assay direct	0.32	.....	.....	.....	0.23	.....	0.15	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

Comparison of results obtained from two different methods as shown in Figs. 12 and 13.

NOTE.—The concentrates from the flotation cells were in both cases retreated in half-size Callow cells, the retreatment tailings being returned to the head of the primary cells.

Tonnage rate in system 1..... Ton per Primary Cells
Tonnage rate in system 2..... 47.5

CONCLUSIONS.—No advantage is apparent in favor of either system. System to be installed should be decided from mechanical points.

VARIATIONS OF FLOW SHEET

In the way of other flow sheet variations, etc., only one thing was tried to any extent; that is, whether it

ative did not believe in small-scale tests, and for this reason did not recommend experiments with small testing machines. Nevertheless, it seemed desirable to have something with which to carry out small-scale laboratory experiments. Dr. Ricketts, who was aware of our troubles and realized the importance of such tests, was kind enough to send us a little electrically operated emulsifying machine, which served admirably for qualitative tests. We also built a testing machine based on the principle of the Standard Minerals Sep-

ration machine, with the difference, however, that instead of sending the pulp from one agitating compartment to a spitzkasten and then into another agitating compartment and spitzkasten, we made the pulp return from the first spitzkasten to the original agitator, forcing it to revolve in a closed circuit. Our laboratory machine is illustrated in Fig. 14. Lately a machine based on the same principle has been put on the market and is sold by the Denver Fire-Clay Company. Thus, we had a chance to try the different fractions of our home-made coal tar.

The chemist who conducted these tests (Mueller) hit on the idea that it might be well, in addition to trying the different fractions, also to test the coal tar as a whole. The results were very surprising, since they showed that by the addition of crude coal tar we could effect a greater recovery than we were able to obtain by the use of highly refined cresylic acid. From this point dates our experience that it is better to use coal tar than soluble flotation agents like cresylic acid to save coarse mineral. Cresylic acid is an extraordinarily good agent for producing froth, but the froth which it produces does not seem to have as much carrying power for coarse mineral as that produced by coal tar. Not all coal tars are equally good for this purpose. Tests in laboratory machines easily show the difference between coal tars of different origin.

The system that we used to carry out such tests has been described, although without authorization, by William A. Mueller, one of my former assistants who took part in these laboratory tests.*

It is difficult to utilize coal tar in plants using flotation supplementary to gravity concentration, on account of the fact that it is not easy to effect a good amalgamation of tar with the pulp in agitating tanks, and even in mechanical flotation machines. The use

of coal tar lends itself very well indeed to the system of feeding tar into the grinding machines, a system that, as mentioned above, had been worked out in our small test mill and patented by Mr. Chapman.

The company is indebted to Mr. Callow for proving the merits of coal-tar creosote as a flotation agent by using it in his demonstration plant at Inspiration. After we had established the value of coal tar by laboratory tests, and while efforts were being made to obtain it commercially, he applied creosote successfully. We have continued to use it for a long time, mostly in combination with coal tar, and have only recently dropped it, as we find crude coal tar cheaper and better.

EXPERIENCE WITH PRIMARY SLIME

After the first difficulty that we encountered in our large-scale tests had been solved by the introduction of coal tar into the flotation-oil mixture so far used, things went along fairly well for some time until a new difficulty was encountered.

It happened that once in a while an abundant froth was produced on the flotation machines, but this froth seemed to have very little carrying power for the mineral contents of the ore and held mainly finely divided gangue. It was observed that this phenomenon occurred with special severity whenever the ores shipped to the test mill contained a large amount of fines and a small amount of coarse rock. It was attributed, therefore to the presence of what may be called primary slime, that is, slime not formed by the crushing of ore in the mill, but originating from the mine.

That the falling down of the flotation machines was caused by variation of the ores was proven by the fact that samples of the refractory ores when treated in the laboratory testing machine, gave as unsatisfactory results as the corresponding ore did in the big flotation machines.

To demonstrate that the presence of the original slime caused the trouble, samples of the mill feed were separated into sand and by screening them on a 200-mesh screen. The oversize, when reduced to the proper fineness for flotation treatment, did not offer the least trouble and yielded a high-grade concentrate in the laboratory machines, while the undersize proved extremely refractory (refer to Table 3).

The same experiment was repeated on a large scale, the products from a Marcy ball mill crushing to about six-mesh being treated on

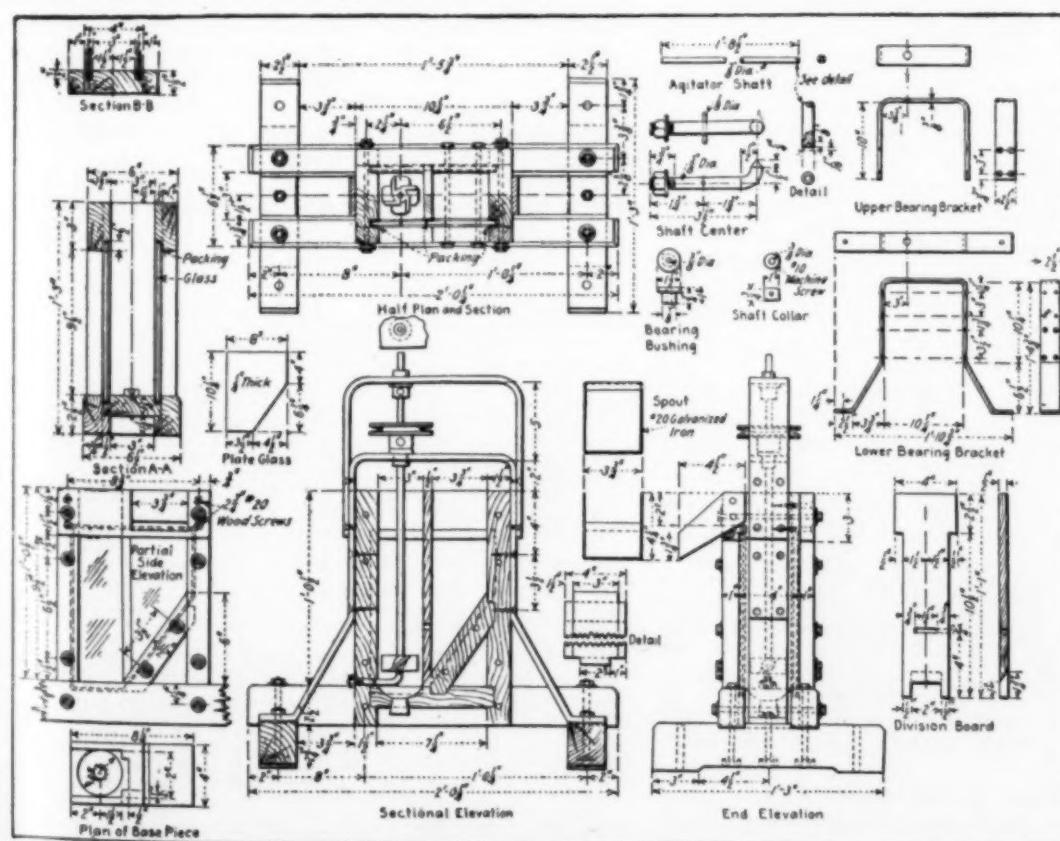


FIG. 14—LABORATORY FLOTATION MACHINE

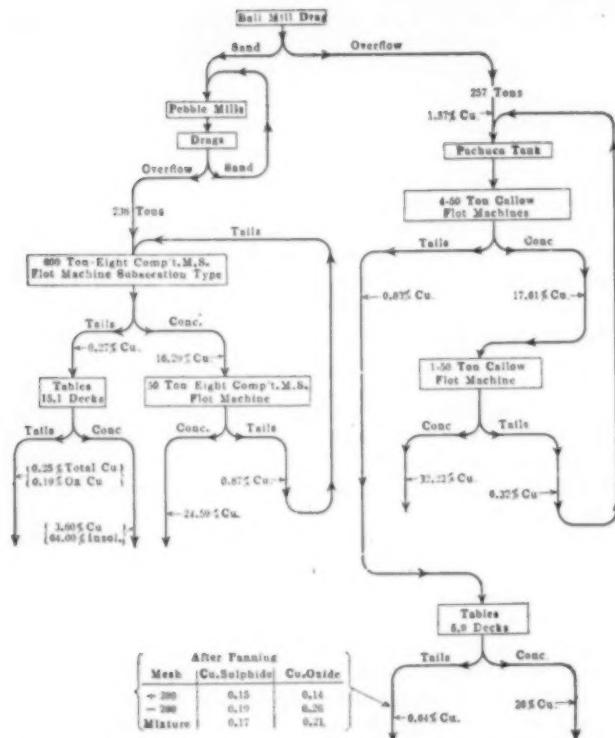


FIG. 15—TESTS TO DETERMINE EFFECT OF SEPARATE TREATMENT OF SLIME AND REGROUND SAND

a drag classifier. The oversize, after being reduced in pebble mills to the necessary fineness for flotation treatment, was sent to one group of flotation machines, while the overflow from the drag classifier was sent to another group.

Fig. 15 illustrates the results of this experiment. While the reground oversize yielded remarkable lean tailings, the product containing the primary slime could not be treated advantageously by flotation.

We were almost on the point of concluding that in

TABLE III—SCREEN ANALYSIS OF ORE DRAWN FROM MILL BINS AND FLotation TESTS OF DIFFERENT SCREEN SIZES

Screen Size	Weights, per Cent		Per Cent Total Copper	Copper Contents	Per Cent Oxidized Copper	Contents Ox. Cu.	Flotation Results		Recovery per Cent
	Cumul.	Indiv.					Tails	Middle + Conc.	
Inches									
+ 1	30.8	30.8	1.05	0.324	0.13	0.40	0.22	12.8	80.5
+ ½	47.9	17.1	1.34	0.329	0.11	0.19	0.22	17.4	84.7
Mean									
+ 4	70.9	23.0	1.44	0.332	0.12	0.28	0.17	17.1	89.0
+ 8	75.2	4.3	1.42	0.061	0.12	0.05	0.17	16.3	88.8
+ 14	80.3	5.1	1.77	0.068	0.13	0.07	0.26	16.8	86.7
+ 28	84.4	4.1	2.14	0.080	0.14	0.06	0.01	16.3	74.3
+ 48	87.5	3.1	2.62	0.081	0.19	0.06	0.72	11.3	77.5
+ 100	89.9	2.4	3.29	0.079	0.24	0.06	0.63	22.5	83.1
+ 200	91.9	2.0	3.16	0.063	0.27	0.05	0.60	20.1	83.5
- 200	100.0	8.1	1.53	0.124	0.43	0.35	1.57	1.48	None
	.....	100.0	1.44	1.441	0.16	0.157			

The + 1-in. and + ½-in. sizes resulting from the screen analysis were ground to 10 mesh, mixed with varying amounts of -200 material and the mixtures ground with the usual amounts of oil in the laboratory ball mills. After this preliminary treatment, the samples were treated in the laboratory flotation machines.

order to get the best results, a separation of the primary slime should be made in our large mill and flotation should not be entirely relied upon for the treatment of the slime.

Before finally deciding on this point, however, some additional laboratory experiments were made to study the influence of the primary slime on flotation. These tests established one fact quite well, which is, that when

refractory slime is mixed with a sufficient quantity of coarse ore ground to the necessary fineness, in other words, when the percentage of primary slime in the flotation feed is kept low, the slime loses its refractory character. I do not mean to say that by reducing the quantity of primary slime, the deleterious influence is reduced in proportion so that it cannot be detected as easily, but conclude from our tests that when the flotation feed contains a sufficient percentage of comminuted coarse rock, the primary slime contained in it can be treated more advantageously than it could by itself.

Some tests bearing on this point are illustrated in Fig. 16. They indicate that as high an amount as 20 per cent primary slime may be mixed with ground coarse ore without causing increased tailing losses.

The concentrates, according to this set of tests, seem to have a tendency, however, to carry more insoluble matter with an increasing percentage of slime.

INFLUENCE OF IRON ON FLOTATION

While these tests were in progress, we made another accidental discovery which proved very helpful to us. In our tests on the most economical way of reducing the ore to the fineness necessary for flotation we had among other machines a ball mill in competition with pebble mills. In the ball mill, steel balls performed the duty that in pebble mills was done by flint pebbles.

For a while the ball-mill discharge was treated on one flotation machine, while the pebble-mill discharge was treated on a group of others. While this flow sheet was being followed, we thought we noted that a flotation machine treating the ball-mill product showed the influence of the primary slime to a lesser extent than the flotation machine treating the pebble-mill product. In a discussion with Dr. Ricketts and Mr. Mills, the question was raised as to whether the iron introduced in the mill pulp by the attrition of the balls might not have something to do with the fact. The question was accordingly made the subject of some laboratory experiments. The results of a series of such experiments are represented in Table 4, and proved conclusively that the iron had a beneficial influence on flotation in counteracting the harmful effect of the primary slime. This discovery was one of the inducements for installing ball mills in the big concentrator.

TABLE IV—EFFECTS OF IRON AND OTHER SOLIDS ON THE FLOTATION OF REFRACTORY COPPER ORES

Test No.	Grams Ore	Per Cent Copper	Grams Copper	CONCENTRATES			Remarks
				Grams	Per Cent Cu	Grams Cu	
F21	750	2.01	15.07	45	23.66	10.65	70.7 Added 10 g. iron filings.
F22	750	2.01	15.07	47	29.52	11.52	76.4 Added 10 g. iron filings.
F23	750	2.01	15.07	43	27.10	11.65	77.5 Added 2 g. iron filings.
F28	750	2.01	15.07	47	26.90	12.64	84.0 Added 2 g. iron filings.
F45	750	2.01	15.07	31	23.84	12.16	80.7 Added 10 g. iron filings.
F46	750	2.01	15.07	48	25.60	12.29	81.5 Added 10 g. iron filings.
F47	750	2.01	15.07	27	8.80	2.38	15.8 Blank with no solids added.
F48	750	2.01	15.07	28	8.34	2.34	15.5 Blank with no solids added.
F49	750	2.01	15.07	62	20.14	12.49	83.0 Added 10 g. miscellaneous iron filings from shop.
F50	750	2.01	15.07	63	20.10	12.66	84.0 Added 10 g. miscellaneous iron filings from shop.
F51	750	2.01	15.07	60	18.82	11.29	75.0 Same as F49 and F50 by different observer.
F52	750	2.01	15.07	62	19.54	12.11	80.5 Same as F49 and F50 by different observer.
F53	750	2.01	15.07	29	6.16	1.79	11.9 Blank with no solids added.
F54	750	2.01	15.07	30	7.96	2.39	15.9 Blank with no solids added.
F55	750	2.01	15.07	59	21.06	12.44	82.7 Added 10 g. iron filings.
F56	750	2.01	15.07	56	25.80	14.45	96.0 Added 10 g. iron filings.
F64	750	2.01	15.07	65	19.52	12.69	81.9 Ground in mill with steel balls instead of pebbles.
L27	750	1.10	12.75	37	28.42	10.51	81.7 Blank on good flotation ore.
L28	750	1.10	12.75	34	28.46	9.85	78.3 Blank on good flotation ore.
L29	750	1.10	12.75	76	5.68	4.30	33.4 Identical conditions as L27 and L28 but added 10 g. zinc filings.
L30	750	1.10	12.75	83	5.06	4.20	32.9 Identical conditions as L27 and L28 but added 10 g. zinc filings.

We have not yet reached a point where we can safely give the reason for the action of the iron introduced into the flotation pulp. It is sure, from the experiments referred to, that the same results, as by grinding with balls, could be obtained by introducing the iron in finely divided form, say in the form of filings, into a pebble-mill pulp. We supposed for a while, and I am not yet certain that this supposition is incorrect, that the metallic iron might react on the impurities contained in solution in the mill water and introduced therein with the primary slime. We find, as a matter of fact, that our ores contain very little in the nature of soluble salts, and that whatever they do contain is mainly confined to the primary slime. For this reason, in laboratory tests we have tried repeatedly to substitute pure water for the water contained in the mill pulp. In every case we have noted some improvements in the results obtained. We have also found that when we separate the water from refractory pulp, treat it with iron filings, and add it to the original pulp again, we get a certain improvement in the recovery, but we

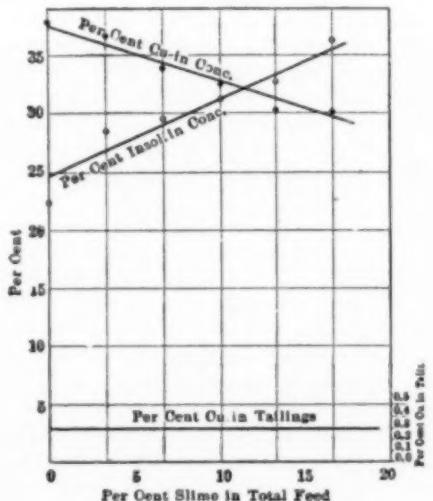


FIG. 16—INFLUENCE ON FLOTATION OF MIXING PRIMARY SLIME AND REGROUND SAND

have not been able to get an improvement equally as good as that obtained by direct introduction of finely divided iron into the pulp.

For this reason, we have often thought that the effect of iron is physical rather than chemical in char-

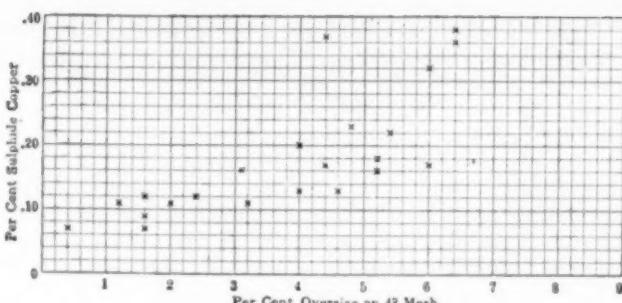


FIG. 18—RELATION BETWEEN COARSENESS OF FLOTATION MACHINE FEED AND COPPER SULPHIDE ASSAY OF CALOW TABLE TAILING

acter. The iron exists in the pulp, at least partly, in the metallic form, as can be proven by the use of the magnet. If necessary the effect of the iron could be increased by removing the iron contained in the tailings pulp by means of electromagnets and returning it to the mills or the flotation machines. Although we have considered the possibility of applying this fact commercially, we have not yet done so.

I have been told by several people that they have tested the influence of finely divided iron on their ores and have not obtained any improvement whatever. This shows, evidently, that metallic iron is not a universal remedy for all flotation troubles, but as far as our primary slime is concerned, our experience leaves no doubt about its usefulness, and I believe the figures quoted above are positive enough to bear out my statement. As a curiosity I have included in Table IV some figures showing the influence of the addition of zinc filings to ore that without the addition does not offer any difficulty in the flotation treatment.

INFLUENCE OF CHEMICALS ON PRIMARY SLIME

We also found that the harmful influence of primary slime can be counteracted by the introduction of certain chemicals; for instance, we have used advantageously sodium hydroxide or postassium cyanide. The use of sodium hydroxide was recommended to us by the Minerals Separation Company, which, I understand, applied it first in the plant of the Caucasus Copper Company.

FINENESS OF CRUSHING DESIRED

Tests to determine the most advantageous fineness for treatment of the ore according to our flow sheet, that is, flotation machines followed by tables, naturally formed an essential part of our tests. Results of this character are plotted in Figs. 17 and 18 and seem to indicate that to get the best results grinding should be carried to such a point that not more than about 1 or 2 per cent of the pulp will remain on a 48-mesh screen (Tyler type). The grinding at our large concentrator is at present carried closely to this point.

(To be concluded)

Powdered Metals in France.—The consumption of powdered metals in France before the war had an annual value of 12,000,000 francs, according to the *Bulletin de la Societe D'Encouragement*. These powdered metals were imported from Germany (none being made in France), and were used in a great variety of products. Since importations have been cut off the manufacture of these powdered metals has been taken up in France by the firm of Caplain-Saint-Andre et Fils at Rantigny (Oise), after conducting preliminary experiments. This company manufactures considerable metal foil and as this is the first step in the powdering process it was natural to take up powdered metals.

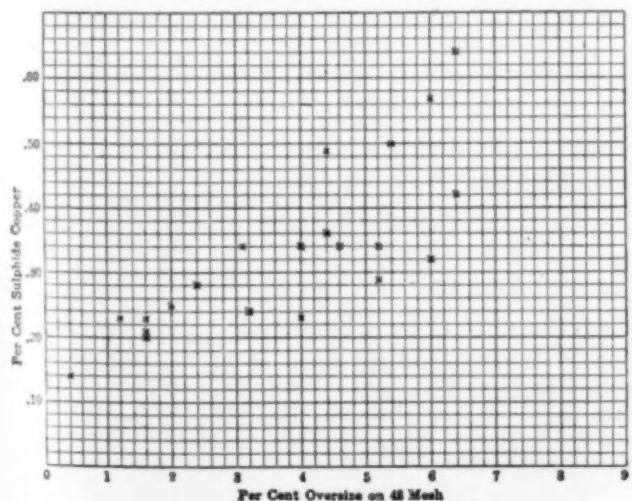


FIG. 17—RELATION BETWEEN COARSENESS OF FLOTATION MACHINE FEED AND COPPER SULPHIDE ASSAY OF CALOW FLOTATION TAILING

Note on the Occurrence and Significance of Twinned Crystals in Electrolytic Copper*

By Henry S. Rawdon

Until recently but scant attention has been paid to the structure and properties of metals prepared electrolytically. This is largely due to the fact that this method of preparation is used primarily as a refining process, and that the metal is to be melted or at least severely worked before being put into the form it will have in service. Copper electrotype plates form an exception to this, the physical properties of such sheets, as deposited, determine to a large degree the wearing qualities of the finished electrotypes. The results of

*A paper read before the American Institute of Metals at the Cleveland convention, Sept. 14, 1916. The complete account will appear in the Technologic series of the Bureau of Standards.



FIG. 1A

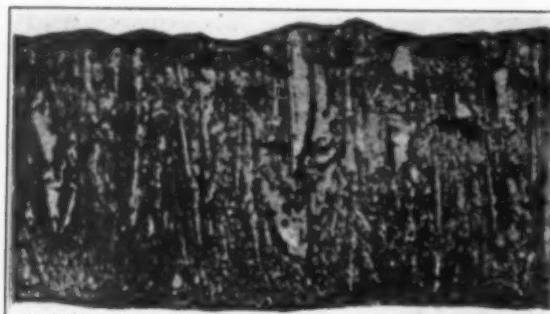


FIG. 1B



FIG. 1C

FIG. 1 (A), (B), (C)—VARIATION IN MICROSTRUCTURE OF ELECTROLYTIC COPPER

the observations referred to below are from the examination made of several series of such electrotype plates, experimentally prepared for the purpose of studying the conditions of deposition which affect their properties.

In the microscopic examinations made the frequent occurrence of twinned crystals was noted. Crystals of this type are common in many metals and alloys, their occurrence being considered as valuable evidence of the history and treatment of the material previous to the time of observation. Until recently such crystals have been regarded as the result of strain and structural distortion followed by annealing. Edwards¹ has, however, recently shown that in the case of tin, zinc, and cadmium at least, such forms can result directly upon the application of mechanical stress without following this by annealing the sample.

In general, the microscopic structure of the copper "shells" observed is in accord with the observations of Sieverts and Wippelmann² and Faust³ upon similar material. Without entering into detail as to effect of temperature, concentration of solution, etc., the microstructures of deposits obtained in the ordinary acid sulphate bath may be summarized as follows: (1) with low current density the crystals are large and well formed, except at the surface of initial deposit, where a thin layer similar to (2) below is seen (Fig. 1-A); (2) with higher current density the crystals become long and finger-like, giving a columnar appearance to the sections as seen under the microscope (Fig. 1-B); (3) with higher current density the structure is considerably broken up and twinned crystals are common (Fig. 1-C). Fig. 2 gives a case showing an excessive amount of twinning.

Copper, in common with most metals, crystallizes in the cubic or regular system. This fact together with the orientation of the various crystals may be demonstrated by deeply etching the polished surfaces used for microscopic examination. The attack is not uniform from crystal to crystal, nor within any individual crystal. The surface of the crystals shows a pitted appearance due to this unequal attack, each pit being in the form of some portion of a cube, the actual shape depending upon the relation of the polished plane to the interior arrangement of each crystal. The pits on any one crystal face are all of the same shape and arrangement.

The crystalline structure corresponding to the "twinned" condition is illustrated in Fig. 2-b by this etching method. Crystals a and a' are twinned with respect to the remainder of the crystal A . The crystalline units, as indicated by the three-sided pyramidal pits (the cut-off corners of the cubes) are all of the same orientation in crystal A ; in crystals a and a' they are oriented alike, but are related to those of crystal A as an object is to its mirror image. In crystals a and a' the structural units, whatever they may be, have been rotated through an angle of 180 deg. so as to assume the position they do with respect to the original arrangement which still persists throughout the remainder of the crystal. Such a rearrangement within a crystal does not happen spontaneously, but requires the application of force to bring it about.

The crystals are twinned to right angles to the direction of "growth," all the twinned layers being parallel within any one crystal. This fact suggests very strongly that they are formed during the process of deposition.

Fig. 1 shows the variations in microstructure of electrolytic copper:

Fig. 1 (a) refers to a current density of 0.41 amp. per square foot, temperature of solution 38 deg. C. The

¹Edwards, Journ. Inst. Metals, XIV, p. 116; 1915.

²Zelt. anorg. Chemie, 1915, 91, pp. 1-44.

³Zelt. anorg. Chemie, 1912, 78, p. 201. Faust also points out the occurrence of twinned crystals in such material.

initial layer adjacent to the cathode face is finely crystalline.

Fig. 1 (b) refers to a current density of 0.57 amp. per square foot, temperature of solution 25 deg. C. This is the common form of deposit, often isolated crystals larger than the average show evidence of twinning.

Fig. 1 (c) refers to a current density of 0.73 amp. per square foot, temperature of solution 25 deg. C. The "twinned" crystals (parallel markings) are numerous in this type of deposit.

Magnification, 300x; etching, 1-1 ammonia hydroxide, followed by immersion in hydrogen peroxide. The lower side, in each case, is the initial deposit, i.e., adjacent to the cathode.

Fig. 2 shows twinned crystals in electrolytic copper:

Fig. 2 (a) refers to a current density of 0.925 amp. per square foot, temperature of solution 28 deg. C. The deposit is unusual in the amount of twinning shown. The metal was deposited from left to right. The twinned layers (alternately light and dark) are perpendicular to the direction of "growth."

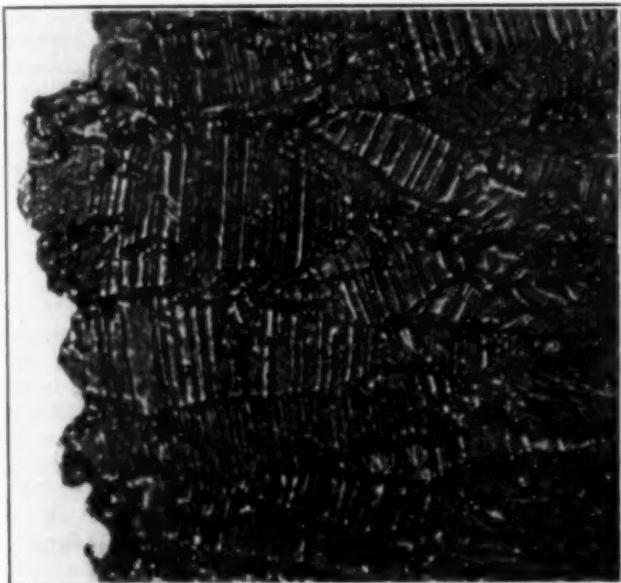


FIG. 2A



FIG. 2B

FIGS. 2 (A) AND (B)—TWINNED CRYSTALS IN ELECTROLYTIC COPPER

Fig. 2 (b) similar to "a" after annealing at 600 deg. C. (approximately). The metal has recrystallized. Magnification, 500x; etching as for Fig. 1.

The simplest explanation of the origin of these twinned forms is that the rotation of the crystalline units comes as a consequence of the side pressure of neighboring crystals during the process of "growth." The condition illustrated by Fig. 1-b is a common one for the conditions used; in such deposits it is often noted that a crystal, which for some reason has grown much faster than its neighbors, is almost invariably found in the twinned condition. The initial layer of the deposit on the cathode face consists of fine columnar crystals closely crowded in together and all "growing" at much the same rate. On account of the small crystal size no twins can be detected in this layer. As the deposit increases in thickness some crystals "grow" at the expense of the adjacent ones which are thus suppressed and "die" out. This is partially due to the tendency of the crystals to grow sidewise as well as outward, as is shown in the increasing width of the fortunate ones as their length increases. The mutual side thrust exerted by the growing crystals is enough in many cases to cause the layer which is being deposited upon any one crystal to assume the position of twinning with respect to the immediately preceding layer.

The occurrence of the twinned crystals in itself, so far as is known, does not materially affect the mechanical properties of a metal. The fact that they are brought about by the application of energy, however, is a very suggestive index of the mechanical properties. It is only when the mutual side pressures upon the crystals exceed a certain value that twinning occurs; in all other cases the metal remains in a state of constant stress, amounting in the effect upon the properties to a virtual "cold working" of the metal. It is a well-established fact that metals which are under stress as a result of "cold working" or other cause have decidedly different properties than when such stresses are relieved.

The hardness of a metal is one of the properties which is notably affected by the mechanical working of the material. Metals highly stressed are much harder than when these stresses are relieved. The hardness measurements of Sieverts and Wipplermann⁴ are in accord with the observations and inferences here made. They found the inner layer directly adjacent to the cathode face to be of nearly uniform hardness in all the deposits measured while the outer side was decidedly softer. A series of measurements made at the Bureau of Standards of the ultimate strength and elongation of specimens cut from the copper deposits is in general accord with the observations of the microstructure. The results obtained for specimens showing the fine columnar type of crystals are uniformly much higher than for the other extreme (approximately two times as much). This is partially due to the difference in crystals; size cut should not be attributed entirely to this.

It has been shown⁵ that upon annealing bronze only in case the metal has been distorted or strained is there any recrystallization occurring. This recrystallization is nearly always accompanied by the twinning of some crystals. The same is true for copper and copper-rich alloys in general. In case the deposits of electrolytic copper are in a stressed condition as has been suggested, upon annealing the metal should assume the characteristic polyhedral forms with the accompanying twinned forms. Several samples showing characteristic types of microstructure were annealed for very nearly

⁴Loc. cit. The hardness was measured by the scratch method using the Martens instrument.

⁵Bureau of Standards Technologic Paper No. 60.

two hours at a temperature of approximately 610 deg. C.

The large crystalline deposits, *i.e.*, those made with low current densities, after annealing show no appreciable change in the crystal size or arrangement (Fig. 3-a). The initial thin columnar layer of such plates, however, has recrystallized and shows frequent twinned crystals. This is in accord with hypothesis; this fine columnar layer adjacent to the cathode face was assumed to be in a state of stress because of its resemblance to those deposits which show the characteristic twinned forms and because of the relatively high uniform hardness of this side. Its behavior upon annealing as recorded in the changed microstructure bears out the correctness of this assumption. The outer large crystals which show no evidence of having been interfered with during their growth, and are consequently in a state of little or no stress, should not be expected to show any recrystallization upon annealing.

Fig. 3 shows the effect of annealing upon microstructure.

Fig. 3 (a) refers to material of Fig. 1-a, after annealing two hours at approximately 600 deg. C. The finely crystalline layer of initial deposit (lower side) has recrystallized and shows twinning; the remainder has remained unchanged. Magnification, 350x.

Fig. 3 (b) refers to material of Fig. 1-c after a similar heating. The entire layer has recrystallized

and shows numerous twins and marked change of crystal size. This appearance is typical for all deposits except those similar to Fig. 1-a. Cold-worked copper after annealing shows a similar microstructure. Magnification, 300x.

Etching as for Fig. 1.

On the contrary, all the other plates annealed, recrystallized into the characteristic polyhedral forms, many of which are twinned. The microstructure has been completely changed, as was to be expected. The parallel columnar type of deposit, even though no twinned forms, or at least few, were found before annealing, has changed as completely as the deposits in which such twins are common.

In order to make certain that the twinned forms observed before long annealing are not due to any slight heating during the mounting and preparation of the specimen for microscopic examination, some samples were mounted between two lead plates and without any heating whatever were polished and examined. The same structure was observed. None of the samples had received any rough treatment, so that the formation of these twinned forms cannot be attributed to mechanical disturbance of any kind. The existence of the metal in a highly stressed condition previous to heating is clearly pointed out by the following decided changes in the microstructure brought about by the annealing: (1) The "recrystallization" of the metal or change to the common polyhedral type; (2) the increase of size of the new form of crystals, and (3) the numerous twinned lamellæ existing in the new structural forms.

SUMMARY

It is to be concluded that the physical properties of electrolytic metals, particularly in the form of thin shells or plates, cannot be ascribed to differences of crystal size alone. The properties of most such deposits are very similar to those of metals "hardened by cold working." It must be concluded, then, from the behavior upon annealing that such deposits, except those at low current densities, are in a condition approximating such a "cold-worked" state, and that the properties are those to be expected from such a condition. Though the study was made for a particular industry, the application of this conclusion in other fields, *e.g.*, electroplating, is obvious.

Bureau of Standards,
Washington, D. C.

The tenth annual meeting of the American Peat Society was held at Washington, D. C., Sept. 21 to 23. The headquarters were at the Hotel Raleigh. Fifteen different papers were presented on the uses of peat and the peat industry by prominent specialists.

Properties of Plastic Fire Clays.—The Bureau of Standards has recently completed an investigation of some European plastic fire clays and published the results as Technologic Paper No. 79. The properties of five well-known European plastic fire clays used in the manufacture of glass refractories, graphite crucibles, etc., have been studied. The content of shrinkage and pore water, the drying shrinkage, fineness of grain, mechanical strength in the dried state, the Atterberg plasticity number, rate of vitrification, and softening temperature have been determined. A comparison is made of these materials as to their suitability for several purposes, and tentative specifications are suggested for the selection of clays which might be used as substitutes for these foreign materials. American clays are available which, if used as mixtures, can take the place of the imported ones with equally as good or superior results.

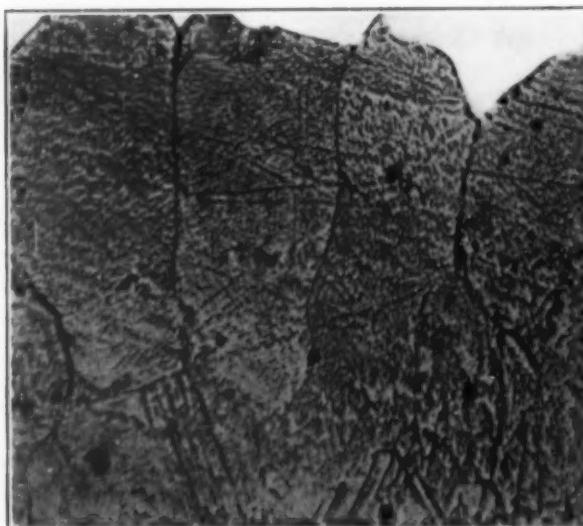


FIG. 3A



FIG. 3B

FIG. 3 (A) AND (B)—EFFECT OF ANNEALING ON MICROSTRUCTURE

NOTES FROM THE PALMER PHYSICAL LABORATORY.

Examination of the Electrical Properties of "Fibrox"

By E. F. Northrup

At the April, 1915, meeting of the Electrochemical Society at Atlantic City, N. J., Dr. E. Weintraub described and showed samples of the remarkable fibrous inorganic material which he calls *fibrox*. Dr. Weintraub generously furnished the writer a sample lot of the material and thus made possible the tests which are described below.

For the benefit of those not acquainted with Dr. Weintraub's paper (*Trans. of the Electrochem. Soc.*, Vol. XXVII, 1915, pp. 267-276) the nature and properties of fibrox are here briefly summarized: Fibrox is formed by the slow chemical union of CO₂ with the vapor of silicon, giving a product of the possible composition SiCO. When prepared in the manner described by Dr. Weintraub, in which it is essential that there shall be a slow interpenetration of the reacting gas and vapor, the resulting fibrox is characterized by the following physical properties:

It is a soft, resilient, fibrous material of a pale greenish-blue color. It can be cut into sheets, or other forms which are self-supporting. If a mass of fibrox is wet with water it collapses into a formless slime.

It is an agglomeration of exceedingly fine fibers which can only be seen by direct vision with the aid of a lens. They are said to be between 0.3 and 0.6 micron in diameter.

The apparent density of the mass is more or less variable with different samples and is given by Dr. Weintraub as 2.5 to 3 grams per liter—though some samples studied by me ran somewhat higher than this.

The volume of air occupied by the mass of the material figures out as about 99.5 to 99.9 per cent. As a consequence of this large air-content the specific heat of a mass of fibrox is exceedingly small and the curious result follows that a mass of fibrox can be held for an indefinite time in a hot flame and then be immediately grasped by the hand when withdrawn from the flame; a slight sense of warmth only being felt. In other words fibrox is a material which cannot be made to stay hot for even brief intervals.

The heat-resistivity of fibrox is most exceptional, and as a heat-insulator, which will at the same time withstand a very high temperature, (in a reducing atmosphere to at least the melting point of Bessemer steel, and probably higher), it has no superior. It runs about 2300 thermal ohms per cm² at 200 deg. C. It is non-hygroscopic.

The most surprising property of fibrox is that, instead of being as one would suppose, a most perfect electrical insulator, it conducts electricity exceedingly well. It is this property that the writer first decided to examine, to above 1100 deg. C.

As will be seen by the results which are given in curves, the variability of the electrical resistivity with measurements made at different times and under different conditions is such that no definite figures of resistivity can be assigned to fibrox in the mass. The curves are of interest, however, in showing the general character of the electrical conduction of this material in the mass and how it is modified by elevation in temperature. No attempt was made to determine how the resistivity might be modified by a change in the current-density of the measuring current. The effect of increasing the current through the sample is given in Dr. Weintraub's paper where it is shown that an increase in current decreases the resistance. My measurements

were all made with about 0.02 amp. (60-cycle current) through the specimen, which presented a section normal to the direction of the current of 15 cm².

The method employed in making the measurements was in all respects identical with the method employed by the writer in his determination of the "High-Temperature Resistivity of Refractories," described by him in METALLURGICAL AND CHEMICAL ENGINEERING, February, 1914.

The samples of fibrox supplied the writer were in several pieces which were not equally dense and coherent. Three slabs of fibrox (to represent average quality) were cut out with a high speed circular saw (which worked very well—better than a razor). The dimensions of each slab were chosen 0.7 cm. thick by 5 cm. long by 3 cm. wide. These three slabs were clamped between graphite slabs in the manner shown in Fig. 1 in the article above referred to. The graphite slabs were drawn together with the graphite screws until the slabs of fibrox were compressed from a thickness of 0.7 cm. to a thickness of 0.2 cm.

Using these dimensions and measuring the resistance between the two terminals of molybdenum attached to the two inner graphite slabs the resistivity per cm.² of the sample is given by multiplying the measured resistance by the factor 112.5. The resistance was measured, using A. C., with a Wheatstone bridge and Rowland electro-dynamometer and the temperatures were measured with a Pt vs. Pt + 10 per cent Rh thermocouple. The sample was heated in the writer's graphite furnace. (See METALLURGICAL AND CHEMICAL ENGINEERING, Jan. 1914), and was exposed to a reducing atmosphere of CO + N.

The procedure was to take simultaneously frequent readings of resistance and temperature as the furnace was slowly heated (the temperature being carried in the first test to 1108 deg. C.) and then to continue taking readings as the furnace was permitted to slowly cool.

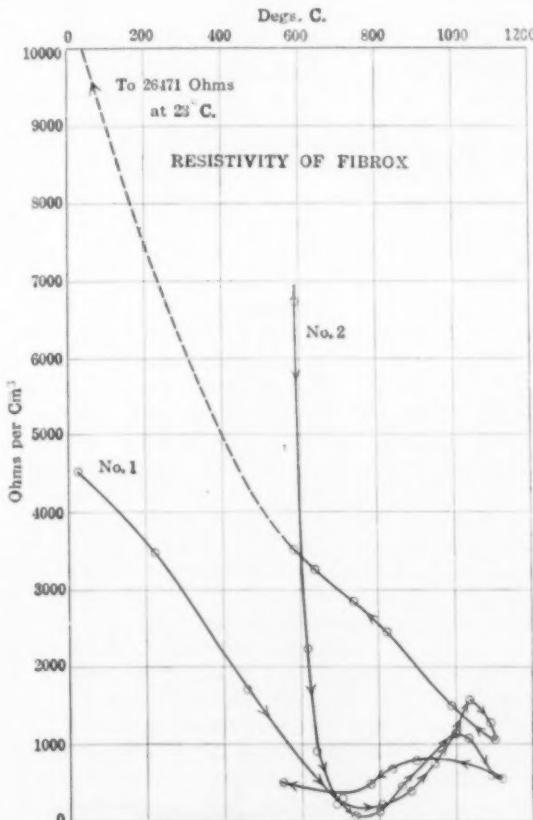


FIG. 1—RESULTS OF FIRST TEST

The results obtained in this first test are shown in curve No. 1.

There is no question but what the curve represents the true and gradual lowering of the resistivity from the beginning of the measurements at a temperature of 40 deg. C. to the highest temperature obtained, 1108 deg. C.

It is very doubtful, however, if any reliance is to be placed upon the course of the curve after the furnace started to cool. The reason for this conclusion is based on the observation made of the sample after the test was completed when it was found that the slabs of fibrox had completely lost all their resilience and were so loosely clamped between the graphite slabs that large contact resistances might easily be present.

The curious inflections in the curve at 760 deg. and 1000 deg. C. are, the writer assumes, real phenomena. To test this assumption the same specimen was measured a second time up to a temperature of 1117 deg. C. Before the second set of measurements was begun the slabs of graphite were drawn together with screws until the slabs of fibrox were again clamped tightly. This reduced the thickness of the latter to 0.1 cm. and made the multiplier 225 to change resistance into resistivity.

It was found that the resistivity at room temperature (26.7 deg. C.) had permanently risen to 33,750 ohms. The resistance, however, fell with great rapidity as the temperature was raised and followed a curious curve No. 2 (Fig. 1) and plotted to a smaller scale, No. 3 (Fig. 2). This curve (No. 2) shows inflections of exactly the same kind, at about 750 deg. and 1040 deg., as did the first curve, which is very strong evidence against their accidental or erroneous character.

It is indeed unfortunate that fibrox is an electrical conductor, for were it a good insulator it could readily be woven into a cloth or compressed into sheets, and thus perhaps solve the problem of an inorganic flexible insulating material. Perhaps some one will be fortunate in discovering some other fibrous inorganic material which will serve this end.

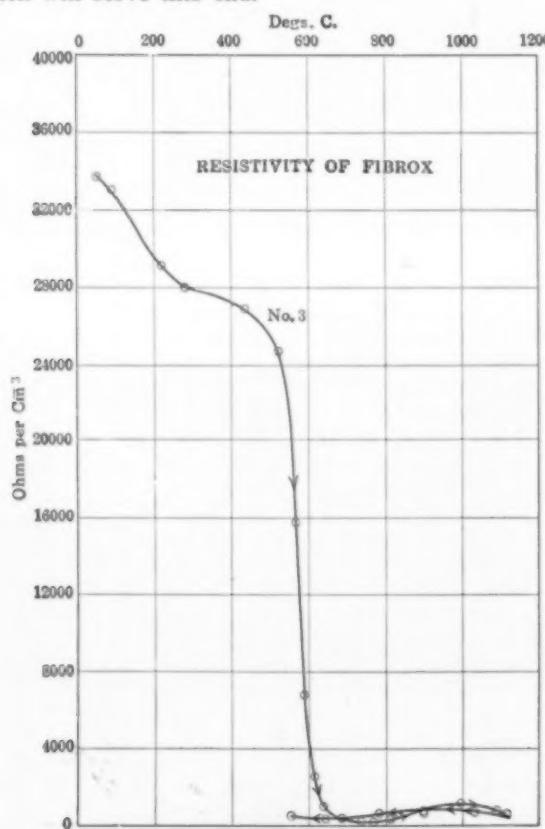


FIG. 2—PLOT OF CURVE NO. 2 ON SMALLER SCALE

In the first determination the lowest resistance read was 1.5 ohms at 760 deg. C., corresponding to a resistivity of 169 ohms, with corresponding figures in the second determination of 0.35 ohm for resistance at 742 deg. C., corresponding to a resistivity of 79 ohms. The question was asked, does the current flow through this low resistance as a result of a chemical dissociation or is the conduction electronic as in metals? If the former were true, it seemed natural to suppose that if a slab of fibrox were clamped between a slab of graphite and a slab of iron (or other metal) that the combination might form a truly dry cell which would develop an emf. and yield a not insignificant electric current.

To test this matter two pieces of fibrox (two pieces used in the previous tests) were clamped between two slabs of graphite with a piece of sheet steel between the two sheets of fibrox. The sheet steel was made one terminal and the graphite clamps the other terminal. This combination was lowered into the furnace and the temperature was slowly raised until the sheet steel melted. The two terminals were joined to a potentiometer and a development of an emf. was looked for. It was found that the combination developed a few microvolts only which were referred to thermal emfs.

There was no evidence that fibrox at any temperature under the melting temperature of Bessemer steel (about 1300 deg. C.) acts as does the electrolyte in a cell. The sample was examined after the furnace cooled. The fibrox was black in color, being discolored by the carbonaceous atmosphere, but there was no chemical action between the steel and the fibrox, although the steel slab with which the two pieces were in contact had been partially melted.

May it not be possible, however, to find materials which are non-conductors at ordinary temperatures, but good conductors at high temperatures, and which would form good "dry electrolytes"? For example, MgO in the presence of carbon is decomposed in the hot zone of a furnace, the magnesium vapor recombining with O in the cooler zones of the furnace. May it not be possible to cause this decomposition to take place under high-temperature conditions whereby an electric current could be obtained at the expense of the consumption of carbon?

The Electrolytic Recovery of Lead from Brine Leaches*

By Clarence E. Sims and Oliver C. Ralston

INTRODUCTION AND HISTORY

The knowledge that lead sulphate and lead chloride are soluble in a strong brine solution and that lead may be recovered from such a brine solution by electrolysis is not new, although certainly not widespread. In fact, as long ago as 1854, M. M. Bequerel, of Paris, reported in *Comptes rendus*, 38, 1095 (1854), of the work he had done on lead leaching and electrolysis. In all he treated about 20,000 lb. of ore, mostly from South American and Mexican sources. His method of procedure was to give the ore a sulphatizing roast in the presence of salt and leach out the lead sulphate and silver chloride with saturated brine. The brine was then electrolyzed to recover the metals. The principles of his process were quite similar to those of the process described in this paper. However, Bequerel could never have made his process commercially practical be-

*A paper presented at the New York meeting of the American Electrochemical Society. Contributed by the Department of Metallurgical Research of the University of Utah, in co-operation with the U. S. Bureau of Mines. Published by permission of the Director of the U. S. Bureau of Mines. Mr. Clarence E. Sims is a Fellow, Department of Metallurgical Research, University of Utah. Mr. Oliver C. Ralston is Assistant Metallurgist, U. S. Bureau of Mines.

cause of the then existing commercial conditions, which are much changed now. For instance, he obtained his current from the only source he knew of, namely the primary cell.

H. R. Ellis claims to have developed, in 1893, a process for leaching oxidized ores of lead with a hot (but not saturated) brine containing some copper sulphate. Mr. Theodore P. Holt, at the mill of the Mines Operating Co., at Park City, Utah, found that, on giving his ore a chloridizing roast and leaching with a 20 per cent salt solution, lead built up in the brine to about 8 lb. (3.6 kg.) per ton of solution. At the Bunker Hill and Sullivan mill, at Kellogg, Idaho, a lead sulphide ore, which could not be successfully concentrated, was given a chloridizing roast and leached with brine, with good results.

However, we believe that Neil C. Christensen was the first one, since Bequerel did his work, to conceive the idea of recovering lead from the brine by electrolysis. His work was done in the Knight-Christensen mill at Silver City, Utah. He had been rather successful in recovering lead in this manner on a laboratory scale, and was taking steps to enlarge his experimental plant, when the mill burned down.

The following work was carried out in the laboratories of the Department of Metallurgical Research of the University of Utah, in co-operation with the U. S. Bureau of Mines, and was undertaken for the purpose of finding a commercially feasible process for the recovery of the values contained in low-grade lead ores, which, for any reason, cannot be recovered by concentration processes of any kind.

METHOD OF EXPERIMENTAL PROCEDURE

The Process. In order to take advantage of the fact that both the sulphate and the chloride of lead will dissolve in a saturated salt solution, carbonate ores of lead were treated with brines containing at least enough sulphuric acid to convert the lead to one of the soluble forms. The sulphide ores of lead were given a sulphate roast, which converted 75 to 99 per cent of the lead to the sulphate form and the rest to the oxide form. Enough sulphuric acid was added to the brines to convert this oxide to a soluble form. These leaching solutions were electrolyzed to recover metallic lead. Various details covering the leaching of lead ores by the use of brines will be published later, the present paper being designed to present an exposition of the necessary conditions for recovering lead by electrolysis of the solutions.

Leaching. The leaching was done in 2-liter acid bottles. Four bottles were used, 8 liters of solution being required in all runs. The ore and brine were put together in the bottles with enough sulphuric acid

to convert all of the lead to sulphate of lead. The bottles were then tightly stoppered and agitated on the rolls, usually from two to five hours, although at times leaches were allowed to run over night. When small amounts of CO_2 were formed, owing to the action of the acid, the stoppers were removed from time to time to relieve the gas pressure. But in ores containing large amounts of carbonate, just enough brine was put in with the ore so that the brine would not run out of the bottle when lying on its side unstoppered. Then acid was put in and the bottle later filled with saturated brine and put back on the rolls for leaching.

The filtering was done in an 8-in. Buchner funnel, using a water suction pump. After the pulp had been drained as thoroughly as possible by this means it was washed with barren brine and then with water. The wash with brine must be given first in order to prevent the reprecipitation of the lead in the ore, because the pregnant brine on being diluted with water precipitates lead chloride. The water wash is to recover the salt in the ore.

Electrolysis. The electrolysis was carried out in a 6.5 x 9 x 12-in. (15 x 23 x 30-cm.) storage battery jar, which holds conveniently 8 liters of electrolyte. The accompanying sketch shows the arrangement of the cell in detail. The electrodes were 6 in. square and were hung by strips over heavy copper wire busbars. The anode, except in the case of the insoluble anode, was of 1/16-in. (1.6 mm.) sheet iron and the cathode of 1/8-in. (3.2 mm.) sheet lead. The cathode and anode were both soldered to the busbars to afford better connection. The insoluble anode was of 3/8-in. (9.6 mm.) carbon. Agitation and circulation of the solution was secured by means of compressed air, which was bubbled up between the plates through holes in the glass tube shown in the sketch. A 0-3, 0-15, 0-30 Weston ammeter and a 0-3, 0-15, 0-150 Weston voltmeter were used for measurements, and a slide wire resistance to regulate the current. As a source of current, two batteries consisting of three 15-amp. storage cells, each, were available.

The lead was deposited as a sponge and was allowed to fall off of the cathode and collect in the bottom of the cell to be recovered later. The free evolution of hydrogen near the end of a run was taken as an indication that the solution was depleted of lead and electrolysis was stopped.

The sponge lead was collected by draining or filtering off the solution in a small Buchner funnel. While in the funnel it was washed several times, sometimes with hot water, and at times a little acid was added to the first wash. The sponge was then pressed to remove most of the water, after which it was quickly dried on the hot plate. In melting it down to solid lead it was placed in a fire-clay or iron crucible with a light cover of charcoal (to maintain a reducing atmosphere) and heated over a gas flame or in a muffle. Samples of the electrolyte were taken with a pipette while the electrolyte was being agitated. Lead analyses were run by the chromate method according to Low. Iron was determined by permanganate titration, both zinc and stannous chloride being used at different times for reduction. Zinc was determined by titration with ferrocyanide. Sulphur was determined gravimetrically by precipitation as barium sulphate.

As a rule, the production of sponge metal in the electrolysis of metal-bearing solutions is to be avoided, due to the fact that most metals, when in the form of sponge, are melted down into bars with great difficulty. It is almost an impossibility to melt down zinc sponge. In the case of the lead sponge, the lead not being an especially active metal, and having a low melting point

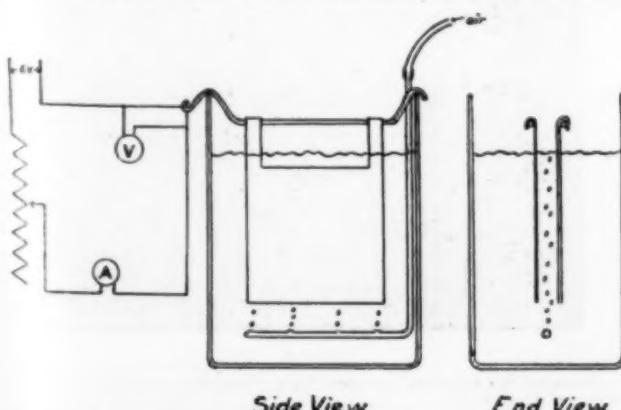


FIG. 1—EXPERIMENTAL ELECTROLYTIC CELL

and as its oxide is easily reduced, the difficulty anticipated did not materialize. In this way electrolysis is not handicapped by the attempt to form reguline deposits of lead.

EFFECT OF CYCLIC RUNS

In starting the series of cyclic runs 8 liters of saturated brine were used. After agitation with ore the brine was filtered off and was then electrolyzed until nearly depleted of lead. It was then run back onto fresh ore for another leach, thus completing one cycle. Enough fresh brine was added to each cycle to replace that lost by evaporation, etc., and to keep the volume of solution up to 8 liters.

Iron builds up slowly in the solution with each cycle until it reaches the neighborhood of 1.5 per cent, when it seems to approach equilibrium. As an amount of iron equivalent to the amount of lead precipitated enters the solution during each electrolysis, then iron must also be thrown out of solution during each cycle. Analysis before and after a leach shows that it is left in the ore. As the leaching solution, although acid at the start, becomes neutral before the end of each agitation with ore, the iron is probably hydrolyzed to either the hydroxide or to a basic chloride. When the electrolysis of the solution has been completed, most of the iron is present as ferrous iron, and it is obviously only the ferric iron which is precipitated. However, it is possible in a neutral solution for the ferrous chloride to oxidize to a basic ferric chloride.

When zinc is present in soluble form in the ore, it goes into solution to a small extent. While zinc sulphate is known to be soluble up to at least 10 per cent of zinc in brine solution, the zinc always remained below 1 per cent in the tests above mentioned.

Sulphates build up slowly and steadily at first. The sulphur is, of course, present largely as sodium sulphate, formed by the double decomposition of the salt and the lead sulphate, when the latter goes into solution. Sodium sulphate is only slightly soluble in saturated brine, however, and readily crystallizes out when present in an amount equivalent to less than 1 per cent of sulphur. Sodium sulphate is different from other impurities in that it is desirable in small amounts, due to the fact that it increases the solubility of lead sulphate in brine. The solution of salt and sodium sulphate, having the maximum solubility for lead, contains about 0.6 per cent sulphur.

Aside from the effect of the sodium sulphate, the solubility of lead in the brine is unaffected by cyclic runs except by lowering the chlorine content.

The cathode efficiency is slightly higher in new brine than it is after impurities have built up in the brine solution. The difference between the cathode efficiency in an old and a new brine is shown in the set of curves in Fig. 2. The cause for the dropping off in efficiency was not definitely determined, although the presence of iron is probably the chief reason, being oxidized from ferrous to ferric iron at the anode, and reduced to ferrous at the cahtode. A search for other causes yielded no results.

GENERAL RESULTS

The saturated brine, after agitation with ore, contained from 1.0 per cent to 1.4 per cent of lead. With proper amounts of ore and brine, and enough acid to convert the lead carbonate or oxide to sulphate, the pregnant brine at room temperature will average 1.25 per cent lead. Under these conditions nearly all of the lead, that is, lead in an oxidized form, will be extracted. A typical example is as follows: Starting with an ore containing 8.86 per cent lead, one leach extracted 71 per cent of the lead. By giving these tailings another

leach with barren brine, a 95 per cent extraction was obtained. Counter current leaching always gave about a 95 per cent extraction of the lead.

The current densities it was possible to use were surprisingly large, considering the very low concentration of lead in the electrolyte. That these current densities were not excessive is shown by the fact that with a current density of 80 amp. per square foot (860 amp. per square millimeter) and a lead concentration of 0.4 to 0.6 per cent, a cathode efficiency of 80 per cent was possible; with a current density of 60 amp. per square foot (645 amp. per square millimeter) and a lead concentration of 1 per cent, a cathode efficiency of approximately 100 per cent was obtained. The set of curves in Fig. 3 shows the relation between lead concentration and cathode efficiency for four different current densities. When the current density goes much above 60 amp. per square foot a great deal of hydrogen is evolved from the cathode. Hydrogen is also evolved at lower current densities when the lead tenor of the electrolyte becomes very low.

By referring to the set of curves in Fig. 3, we find that the best current density at which to start an electrolysis is 60 amp. per square foot. This should be maintained until the lead tenor falls to about 0.7 per cent, and then it should be dropped to 40 amp. per square foot (430 amp. per square millimeter). When 0.3 per cent of lead is reached the current density should be dropped to 20 amp. per square foot (215 amp. per square millimeter), and electrolysis stopped when

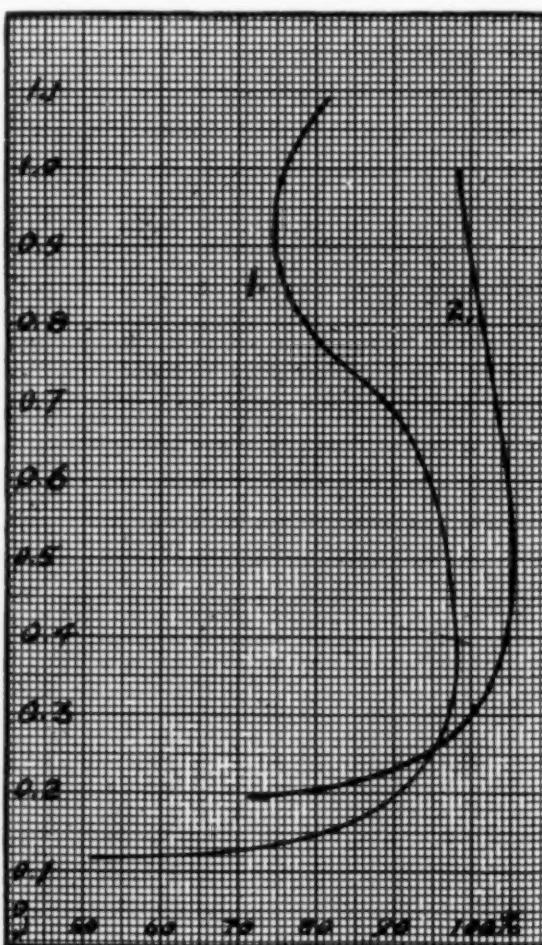


FIG. 2.
Showing the relation between the curves obtained from pure and impure electrolytes.
Abscisse, cathode efficiency in per cent. Ordinates, concentration of Pb.
No. 1. Curve obtained from impure electrolyte.
No. 2. Curve obtained from pure electrolyte.

the lead content falls to 0.1 per cent. The cathode efficiency will vary in two different runs having conditions as nearly alike as possible. One unexplained phenomenon is that the cathode efficiency was always lower at the beginning of an electrolysis than it was a little later in the run. This was also true if the electrolysis was stopped in the middle of a run and started again after an interval of time. It was thought at first that the ferric iron being reduced to ferrous iron at the beginning of the run was the cause of the low efficiency at the start, but it was found that the same thing occurred when no iron was present in the electrolyte. The cathode efficiencies on the whole are encouragingly high. In fact, during the greater part of most of the runs in which 40 amp. per square foot or less were used the cathode efficiency was somewhat over 100 per cent, averaging about 104 per cent. These results may have been due to errors, but the work was carefully done, time measurements and current measurements being proved accurate and check samples being taken for analysis in each case. These results, therefore, compare very favorably with those obtained by Norman M. Bell, who found mono-valent lead dissolving from a lead anode during an electrolysis. (See Trans. Faraday Soc., 11, 79-90, 1915.)

The voltage was very low, the average voltage for different current densities being as follows:

Current Density		
amp. sq. ft.	amp. sq. m.	Voltage
80	8.60	1.2
60	6.45	1.0
40	4.30	0.7
20	2.15	0.5

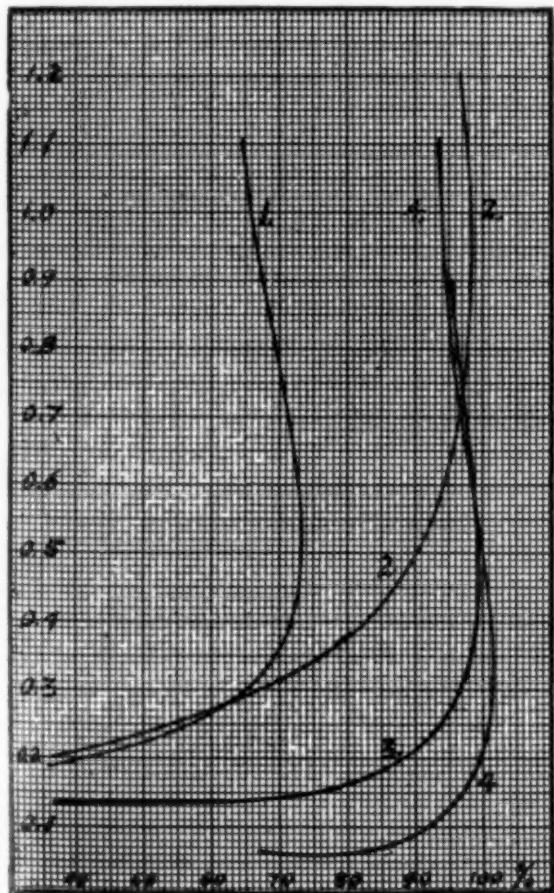


FIG. 3.

Showing the relation between cathode efficiency and concentration of lead in the electrolyte at different current densities.

Abscisse, efficiency in per cent. Ordinates, concentration of Pb.
Curve No. 1. At a current density of 80 amp. per square foot.
Curve No. 2. At a current density of 60 amp. per square foot.
Curve No. 3. At a current density of 40 amp. per square foot.
Curve No. 4. At a current density of 20 amp. per square foot.

The cause of the low voltage is evident. The solution tension for iron is 0.42 volt and that of lead 0.12 volt as compared with zero for hydrogen. Therefore, the anodic solution of iron gives more energy than is necessary to precipitate lead cathodically. In fact, there is an initial voltage of 0.1 volt across the electrolytic cell before the external voltage is impressed. As no gas is formed there is no overvoltage of hydrogen or oxygen. Therefore, the impressed voltage is needed only to overcome the resistance of the electrolyte.

Owing to the high cathode efficiency, low voltage, and high electrochemical equivalent of lead, the power consumption per pound of lead is very low. With a current density of 20 amp. per square foot, which means a voltage of 0.5 volt and a cathode efficiency of 100 per cent, as much as 17 lb. (7.7 kg.) of lead per K. W. H. may be deposited. This weight of deposited material is not even approached in the electrolysis of any other metal.

In one set of tests five electrodes were connected in series the same as in the copper series refining process, that is, the intermediate electrodes served as both anode and cathode on opposite sides. The comparison of series with multiple connections is as follows:

At a current density of 60 amp. per square foot:

	Series	Multiple
Cathode efficiency	62.2%	95%
Lead per K. W. H.	4.59 lb. (2.1 kg.)	6.83 lb. (3.1 kg.)

At a current density of 40 amp. per square foot:

	Series	Multiple
Cathode efficiency	68.9%	95%
Lead per K. W. H.	7.83 lb. (3.6 kg.)	8.65 lb. (3.9 kg.)

At a current density of 20 amp. per square foot:

	Series	Multiple
Cathode efficiency	63.2%	100%
Lead per K. W. H.	12.7 lb. (5.8 kg.)	16.1 lb. (7.3 kg.)

In the series connections of the electrodes neither the cathode efficiency nor the power efficiency is as high as in the multiple connections. The advantage obtained by the series connections, from a commercial standpoint, is: (1) a saving of the space taken up by the cathodes and a saving of the cost of the cathodes, and (2) smaller busbars because of the higher voltage and lower current required. On the other hand, the cathodes and busbars are permanent, and it would be only the first cost of installation that would be higher in the case of the multiple connections, while running cost would be lower because (1) more lead would be obtained per K. W. H., and (2) the cathode efficiency being higher the ratio between the amount of iron consumed and the lead deposited would be greater.

The trials with the insoluble carbon anodes gave very poor results. In the first place the voltage was high. There are two causes for the increase in voltage over that obtained with the iron anodes. First, there is no energy obtained by anodic solution, and, second, there is the high overvoltage of the chlorine on the carbon anode. The voltages were as follows:

Current Density amp. sq. ft.	Voltage
80	2.6
60	2.3
40	2.1

The cathode efficiency near the beginning of the run was around 70 per cent, but fell rapidly. The brine absorbed large quantities of chlorine and became colored a dark greenish-yellow. This dissolved chlorine attacked the deposited lead sponge chemically and dissolved it nearly as fast as it was being deposited.

The deposit of lead sponge is much more compact and more easily recovered when deposited at a lower current density. When a very high current density is employed the lead sponge is fluffy, and being filled with bubbles of hydrogen it floats on the surface of the

electrolyte. It was also noticed that when the electrolyte was slightly acid rather than neutral that the lead sponge assumed a loose crystalline structure, in which form it could be more easily washed, could be dried more quickly with less oxidation, and could be melted down more readily.

Silver follows the lead in electrolysis. When treating an argentiferous ore from the Horn Silver Mine of Frisco, Utah, some of the lead sponge assayed over 100 oz. of silver per ton. This silver could be recovered from the lead by Parke's process, or could be recovered from the solution before electrolysis by precipitation on sponge lead or on iron. A sample of lead obtained from some calcined tailings, after being melted and cast into an ingot, was sent to the U. S. S. R. & M. Co. smelter at Midvale. The chemist there analyzed it and reported negligible impurities. It seems, therefore, that silver is the only substance of any importance that remains with the lead through the melting down treatment. Because of the very pure lead obtained it would probably be best to remove the silver before electrolysis and so avoid desilverizing the lead bullion.

ESTIMATED COSTS

The accompanying sketch of a commercial size electrolytic cell shows how one might be built for the electrolysis of the brine solutions of lead. On a cell of this design, the electrodes may be connected either in series or multiple. The drawing shows the arrangement for multiple connections. The arrangement for connecting in series would be the same except that the cathodes would be absent, and instead of having busbars down the sides, only the end plates would be connected with the external circuit. The pregnant solution would flow into one end from a feed launder and overflow at the other into a discharge launder. Agitation would be by air from holes in the six pipes running along under the electrodes. The sponge falling off of the plates would collect in the center of the V bottom and be carried to one end by the screw conveyor and then be discharged through the hopper arrangement along with a small amount of barren solution.

Because of the very high current densities used the multiple connections are out of the question, owing to the immense size of busbars that would be necessary. Therefore, estimates and calculations will be made on a process using a cell in which the electrodes are connected in series.

Following is an estimated cost of the erection of an electrolytic plant, exclusive of the leaching plant, to produce 10 tons of pure lead per day.

It will be noticed that a margin of from 10 to 20 per cent excess is allowed on all estimates above calculated figures.

In an electrolytic cell such as is shown, using series connections, forty-one electrodes may be used. The electrodes being 3 ft. square, there will be $3 \times 3 \times 40 = 360$ sq. ft. (33.5 sq. m.) of cathode surface. Using a current density of 40 amp. per square foot (430 amp. per square millimeter), which is conservative, and from

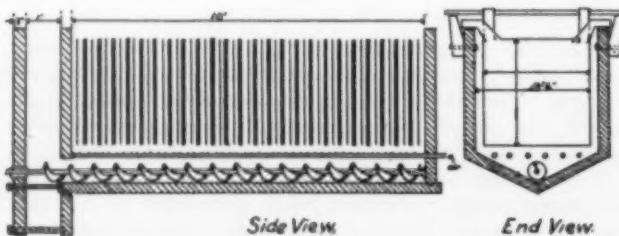


FIG. 4—COMMERCIAL SIZE ELECTROLYTIC CELL

data obtained assuming a cathode efficiency of 70 per cent, we have:

$$\frac{360 \times 40 \times 0.70 \times 103.5}{96,500 \times 1000} = 38.6 \text{ kg. per tank per hour.}$$

$$38.6 \text{ kg.} = 85 \text{ lb. per tank per hour.}$$

$$85 \times 24 = 2040 \text{ lb., or 1 ton per tank per day.}$$

Therefore, ten tanks would produce 10 tons lead per day.

The drop between electrodes will be about 0.7 volt.

$0.7 \times 40 = 28$ volts. 40 volts will be allowed for each tank.

$$40 \times 10 = 400 \text{ volts for ten tanks.}$$

Therefore, figures will be made for a 450-volt generator to deliver 400 amp., 360 amp. being needed.

$$\frac{400 \times 450}{1000} = 180 \text{ kw.}$$

A 200-kw. motor-generator set will therefore be needed. The excess power would be used in compressing air, operating pumps, etc.

By empirical measurement it was found that about 0.5 cu. ft. of air per minute is necessary for a 3-ft. length of electrode in order to give sufficient stirring of the electrolyte. Therefore, $40 \times 0.5 \times 10 = 200$ cu. ft. of air would be required per minute for all of the tanks. 300 cu. ft. will be supplied.

Knowing the size and amount of equipment the estimated cost would be as follows:

One 200-K. W. motor-generator set, 450-volt, 400 ampere..	\$3,500
One 200-K. W. transformer, 45,000 to 560 volts.....	2,100
Ten wooden tanks at \$100 per board foot, including construction, \$50 apiece.....	500
Copper bus-bars, 0.5 inch in diameter, 100 ft., 64-lb. per 100 ft., at \$0.30 per lb.....	30
Piping, 800 ft. at \$0.165 per ft.....	130
Launders	100
Positive pressure blower, 300 cu. ft. at 3 lb.....	420
Motor for blower, 25 H. P.	350
Small reverberatory for melting down 10 tons lead per day.....	500
Lower plant building, \$8 per sq. ft.....	3,000
Electrolytic plant building, \$2 per sq. ft.....	4,000
Miscellaneous equipment	2,000
Total cost, erected.....	\$16,630

Costs of the leaching plant are not included in the above total, but have been variously estimated from \$10,000 to \$15,000, including crushing equipment and housing. In case a sulphide ore is being treated, the cost of roasters will also have to be considered.

OPERATING COSTS

For operating costs, the following figures are approximate. They are made on the assumption that the material used is a mill tailing containing 10 per cent lead in an oxidized form. The iron anodes are assumed to consist of cast iron, 1 in. in thickness:

Leaching ¹ hundred tons at \$0.80 per ton (for Horn Silver Mine ore)	\$80
Iron (estimating that 1 lb. iron is used for every 3 lb. lead deposited, and that it costs \$40 per ton in anode plates), 3.3 tons	132
Power, 200 K. W. at 0.8c. per K. W. H.	38
Labor, one foreman and four helpers on each of three shifts	57
Coal, 1 ton per day	3
Insurance and interest	20
Total for ten tons lead in one day	\$330
Cost of producing one ton lead	33
Value ² of one ton lead at 2 1/4 c. lb.....	55
Estimated margin of profit	\$22

CONCLUSIONS

The investigation on the electrolysis of lead in brine solutions is by no means complete. In the experimental work there is still a great deal to be learned about the

¹The leaching cost is calculated from the known acid requirements of a certain ore which contains a large amount of lead sulphate and only a small amount of lead carbonate. For most ores more acid would be required and hence the leaching cost would be higher.

²It will be noticed that the value of the lead is calculated on a 2 1/4 c. per lb. basis. This is for the reason that in Utah, where this process has been developed, the cost of transportation to lead markets and refining is 1 1/4 c. per lb. Hence our estimate really assumes a 4c. market. As a very pure lead can be obtained it is probable that only transportation costs need be considered, thus materially increasing possible profits.

causes of low cathode efficiencies; how the iron is thrown out of solution, conditions for obtaining the maximum concentration of lead with the smallest acid consumption, etc. The working details of a commercial plant have not been thoroughly worked out.

It would seem at first that it would not be possible to profitably electrolyze a metal of as low a value as lead. But when one considers the cheapness of the leaching agent and the high electrochemical equivalent of lead, together with the wonderfully high efficiencies possible, the problem assumes a different aspect.

If the process should be applied to mill tailings or a mine dump it looks as if a fair profit might be made. However, considering the low value of the product obtained, a 10 per cent material could not be worked if a mining charge of several dollars a ton were added to the cost, although a lead carbonate deposit near the surface could stand considerable of a mining charge if a 15 to 20 per cent ore were obtained.

Although electrolytic precipitation of the lead from brine leaching solutions is the principal subject discussed in this paper, the Department of Metallurgical Research of the University of Utah, in co-operation with the U. S. Bureau of Mines, has likewise been testing other methods of precipitation, and modified methods of leaching. We believe that such a method of treating lead ores will be found applicable to those ores at points distant from lead smelters, which are too low grade to ship, and which for any reason refuse to yield, as before stated, to gravity concentration. Many lead carbonate ores are of this type.

Salt Lake City, Utah.

Synopsis of Recent Chemical and Metallurgical Literature

Carbolic Acid Manufacture in Germany.—A method for recovering carbolic oil from coal tar and some data on carbolic acid in Germany were given in a recent article by Dr. F. RASCHIG, in *Zeitschrift fur Angewandte Chemie*, and abstracted in the *Chemical Trade Journal*. Dr. Raschig says that before the war the carbolic-acid requirements of Germany were met for the most part by the importation from England of crude carbolic acid, which was worked up into pure products in Germany. Germany was dependent upon foreign crude material because English tars are extraordinarily rich in carbolic acid and are obtained in ample quantities, while German tars are poor in carbolic acid, and, until the end of last century, small in production—not one-third of the tar production of Great Britain. The war cut off English supplies of crude carbolic, and also increased Germany's requirements. There is, says Dr. Raschig, an appreciable shortage of carbolic acid in Germany, and he adds the opinion that "the shortage will become more pronounced after the conclusion of peace, when the foreigner will again have access to us, and the large orders which were formerly placed in Germany will be renewed."

Dr. Raschig describes how a carbolic oil containing from 25 to 30 per cent of phenols can be prepared, and mentions that factories for the extraction of these from the oil are in existence or will shortly be erected, to which he suggests the smaller tar distilleries should send their oil. The starting point in the process for producing this carbolic oil is the middle oil of the tar distillation, the fraction coming over at about 170 deg. to 250 deg. C. After separation of about half of the naphthalene content the fraction is again distilled under vacuum. An oil which boils at 170 deg. to 200 deg. C. under atmospheric pressure distils at about 100 deg. to 120 deg. under vacuum, and therefore the apparatus

can be heated by indirect steam at a pressure of 6 to 8 atmospheres. In this way a constant source of heat is obtained, and the distillation proceeds uniformly, independently of the personal equation of the operator. In the ordinary way of vacuum distillation, samples cannot be collected at the moment of coming over, but with the vacuum method devised by Dr. Raschig the distillate is collected in the open, and can be sampled as it comes. Vacuum working necessitates the condenser being placed at least 12 metres (about 39 ft.) above the boiler, and the use of a fall tube of equal length. A special fractionating column designed by Dr. Raschig is also employed, and this he uses as much as 14 metres (about 45½ ft.) in height.

Dr. Raschig claims that German gasworks tar and coke-oven tar could yield annually about 6,000 tons of crystallized carbolic acid, as against scarcely 2,000 tons now obtained. He adds that Germany can produce a quantity of synthetic phenol, but this process requires large quantities of benzene and sulphuric acid, both of which can at present be more usefully employed for other purposes.

Device for Premelting Ferromanganese.—An interesting device for premelting ferroalloys shown in Fig. 1 was described in *Iron and Coal Trades Review*, Aug. 25, 1916. It comprises a melting compartment, built as an extension to the back wall of the furnace, in which ferromanganese and other final additions are melted by the heat of the furnace. Referring to the

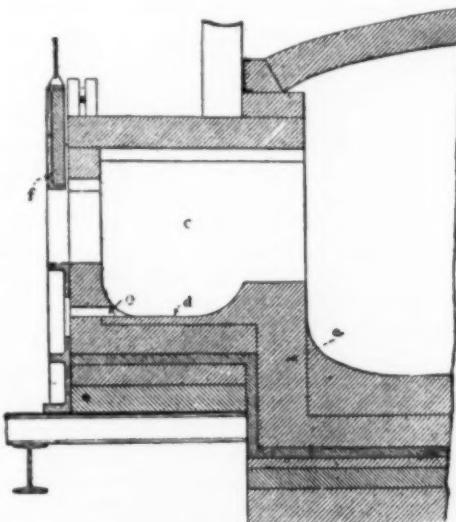


FIG. 1—CROSS SECTION OF AN OPEN-HEARTH FURNACE, SHOWING THE ADDITIONAL CHAMBER FOR PREMELTING FERRO-ALLOYS

illustration, *a* is the back wall of a furnace, against which, and preferably adjacent to the top hole is the chamber *c* open to the interior of the furnace. It has a melting hearth *d* and a tap hole *e*, and is closed by sliding door *f*.

The final additions, such as ferromanganese, ferrosilicon, spiegeleisen, ferrochrome, etc. are charged through this door and are melted by the heat of the furnace. The device is patented by Messrs. Wheeler & Blair (England).

Corrosion of Tinned Sheet Copper.—In a paper presented at the annual meeting of the American Institute of Metals at Cleveland in September, PAUL D. MERICA described an investigation of a curious case of corrosion of tinned sheet copper which formed part of the roof of the Library of Congress in Washington. (A fuller account of the investigation will be published as

a Circular of the Bureau of Standards.) The greater part of the roof of the Library is covered with tinned sheet copper which was installed in 1894. The sheet is 16 oz. tinned on both sides and lies on cement or terra-cotta.

The lower or under side of this sheet has become but little altered in the course of time, except that it has become blackened at the points where the sheet is perforated by the holes described below. The upper or exposed side has taken for the most part, a dark, slightly greenish patina, which is dense and coherent, although in some areas there is a whitish tinge due to the tin or tin oxide. On this surface are found in fairly dense distribution, small pits or furrows, of which the diameter or width varies from $1/32$ to $1/64$ in., the furrows being sometimes as much as 2 inches long. In many sheets there will be as many as 100 per sq. ft., in others, much fewer; often these pits extend completely through the sheet as perforations, through which leakage takes place. The edges of these pits are exceedingly sharp and well defined, much more so than the photograph indicates; their inside surfaces are sometimes covered with a thin reddish or black layer of copper oxide, often, also, with a thin green layer, which is probably basic copper carbonate. It was stated that they had first been noticed some 8 or 10 years after completion of the roof.

A preliminary examination and chemical analysis of the material from the roof of the Library of Congress (B. S. No. 1054) showed that the tin coating contained:

Tin	89.5 per cent	Lead	8.0 per cent
Iron	1.0 per cent	Zinc	1.5 per cent

In order to study the structure of the coating, the sheet was first copper plated on both sides, and then mounted in plaster of Paris (sometimes also in solder). Specimens also were bent slightly, ground and polished on the convex side through both the protecting copper plate and the coating; such a section will be called an oblique surface section. Etchings to develop the structure was done successively with an ammoniacal solution of copper ammonium chloride and with a hydrochloric acid solution of ferric chloride.

The conclusions drawn from the experiments were as follows:

"The explanation of the local character of the corrosion of the tinned sheet copper roofing material seems, therefore, fairly clear. Along the line of scratches, tool marks, etc., the thin coating of tin (thickness, about 0.012 mm. in average) was penetrated and the copper underneath exposed. This copper is in contact with an alloy layer, which is proved to be electro-negative, and less readily corrodible, than the copper; at these points the copper and the alloy layer form a galvanic couple, the copper being attacked more readily than if the alloy were not there.

"It therefore appears that this type of corrosion is possible, inherently, in any sample of tinned copper, since the present process of tinning always produces this intermediate layer of alloy, which acts as an accelerator of corrosion, once the underlying copper is exposed. Many instances are on record, however, of material exactly similar to that described above, which has been in service for 25 and 30 years under much more severe service conditions than those of the Library of Congress, and which has not shown signs of such pitting. Explanation of the variation of resistance to local corrosion of different samples of the same type of material must be sought in the variation of the amount of mechanical abuse given it in service, such as the scratching of the surface, etc., and in the matter of the uniformity in thickness and structure of the tin coating. It was noted that the protecting layer

of eutectic was of quite variable thickness in the sample 1054, and that there were often breaks in the continuity of both the alloy and the eutectic layer, which would also aid in accounting for the initial penetration of the coating.

"The presence of the small amounts of iron and zinc in the coating must also not be lost sight of in this connection; it is possible, although it has not yet been possible to prove, that the presence of these impurities may have contributed toward the initial corrosion of the coating, exposing the copper underneath.

British Dyestuff Manufacture.—The progress of the dyestuff industry in England is described in the recent directors' and managers' reports of British Dyes, Ltd. (Published in the *Chemical Trade Journal and Chemical Engineer*.) It contains considerable matter of interest to dyestuff manufacturers in this country.

The issued share and loan capital of the company consisted as at Aug. 1, 1916, of: Share capital subscribed (864,179 shares of £1 each—10s. per share called up), £864,179; loan from government, £1,064,179; making a total of £1,928,358. Since the date of the report submitted to the statutory meeting of the company (July 5, 1915), the subscribed share capital has increased by £208,080, and the loan to which the company is entitled from the government has increased by £209,629, making together an increase of £417,709.

The Board of Directors have established:

(1.) *A Committee of Directors.* This committee gives continuous attention to the affairs of the company.

(2.) *A Technical Committee.* This committee combines the heads of the technical and scientific departments with Dr. Forster as chairman.

(3.) *A Research Department*, of which Prof. W. H. Perkin is the head. On account of the delay and expense which would have been involved in erecting during the war a central research laboratory it has been arranged that in the meantime the research work, so far as not conducted in the works laboratories, should be carried on in the laboratories of different universities under the supervision of the professors of organic chemistry. Research colonies have been established in this way employing a number of assistants under the respective professors, and much important work is being carried out.

(4.) *An Advisory Council*, which consists of twelve eminent professors of chemistry connected with different universities in addition to the members of the Technical Committee. It has been formed for the purpose of increasing the number of chemists and promoting research in organic chemistry, and particularly in that branch of it which relates to coal-tar colors. The company has offered to place at the disposal of the professors an annual grant for the remuneration of honor graduates in chemistry who have received special instruction in coal-tar products and who are prepared to continue their training as research assistants. After such training the company will be prepared to offer employment to suitable men recommended by the professors. The directors have also agreed to make a grant of £5,000 towards a scheme for the development of advanced teaching and research in tinctorial chemistry in the Technical College at Huddersfield.

Notwithstanding the restriction caused by the shortage of certain materials owing to the war, the supply of dyes from the company's works has been greatly increased. New plant has been erected and is in course of erection for further increasing the supply of those dyes which are most in demand and which can be made in large quantities from the materials available. In the near future the supply will be further substantially

augmented. The company has also sent to the Swiss manufacturers considerable quantities of raw materials and intermediate products, without which they would not have been able to continue their supplies to the British markets.

A committee appointed by the Board of Trade has made an exhaustive inquiry into the color requirements of this country. Mr. Turner, the manager of the company's works, who represents the company on the committee, has, with the authority of the Board of Directors, submitted proposals for the prevention of overlapping in manufacture and for utilizing the resources of all dye-makers in the country to the fullest advantage.

After conferring with a number of the leading users of dyes, the directors decided, so far as the new works are concerned, to provide in the first place mainly for manufacturing on a large scale raw materials and intermediate products. They desire to call particular attention to two important considerations:

(1.) In order to secure a permanent national supply of dyes it is imperative that the manufacture of the intermediates from which dyes are made should be successfully established in this country.

(2.) The production of these intermediates requires the operation of a series of processes not hitherto worked on a commercial scale in this country, and it also requires complicated and expensive plant.

A large amount of research and experimental work has been done, and a considerable quantity of plant has already been erected for the production of intermediates. Other important plants are in course of construction, including plants for paranitraniline and betanaphthol.

As regards raw materials, the benzole and phenol plant has been largely increased. An acid plant sufficient for the requirements of the company is approaching completion, and a large part of it is in operation.

When the Turnbridge Works of Messrs. Read Holliday & Sons, Ltd., were acquired by the company, considerable extensions were in course of construction by that company, and these have been completed. After careful inquiry with regard to sites elsewhere an additional freehold site, extending to 343 acres was acquired at Huddersfield. A railway connecting this site with the Turnbridge Works and with the London & North Western Railway has been constructed, which, with its branches and sidings, extends to about eleven miles of single line. Buildings for the accommodation of a large amount of plant have been completed at Turnbridge Works and on the new site. A portion of the new plant has been installed in these buildings, and important materials and products for making dyes are being obtained from it, including a supply of the acids required. A large amount of additional plant is in course of manufacture and erection. A new works laboratory has been completed at the Turnbridge Works, and a oratories will give suitable accommodation to the staff second, including provision for large-scale experiments, is approaching completion on the new site. These lab-of chemists, which has been largely increased. Works and plant for the supply of water, ice, electricity, and steam are in course of construction, and are partly in operation.

The construction of the additional works and plant has been carried on under conditions of special difficulty as regards time and cost on account of the scarcity of the materials and labor required for such work, and of the difficulty in obtaining deliveries of the plant from the makers, and also because a large part of the work was carried out during a winter of exceptional inclemency. Nevertheless, substantial progress has been

made, the total contents of the new buildings erected at the old and new works being not less than 25,000,000 cu. ft. and the floor area covered 1,200,000 super. ft. (about 27 acres.)

The directors propose to arrange for the shareholders to have an opportunity of examining the works.

As the result of conferences with a commission specially appointed by the French government, the board has adjusted a provisional agreement with Le Syndicat National des Matieres Colorantes (a national company which has been formed in France with the support of the French government.) This agreement provides for a complete exchange of knowledge and processes and for the formation of an inter-allied company to establish co-operation between the two companies in regard to the production of intermediates and dyes.

Mr. J. Turner, manager of the company's works, reports as follows:

"During the year the difficulties that we have had to contend with have been very numerous, including shortage of labor and difficulty in getting in machinery and materials, and, in addition, there has been a great shortage of several of the raw materials. Notwithstanding these drawbacks we have been able to make considerable progress.

"During the year we utilized our steamer on several occasions to bring fuming acid from America, not only for our own consumption, but also for consumption by the other color makers in the country. This has enabled them and us to get a larger production than we otherwise could have done, and it has also materially helped the supply by enabling us to send materials to Switzerland, in consequence of which the Swiss companies have been able to continue their supplies of dye-stuffs to this country.

"The erection of our oleum plant is nearly completed, and a large part of it is in operation. This should alleviate the position for the future and enable us to give a larger output than we are doing at present, and also a greater variety of colors. The plant is a large one, and should be capable of producing all the oleum required by us when it is in full working order. We have also erected an additional nitric acid plant, and a large part of this is in operation.

"We have largely increased our plants for the production of benzol, toluol and phenol, and also for the manufacture of dimethylaniline, and these should be sufficient to supply all our requirements after the war.

"At the beginning of the war our arrangements for producing sulphur colors, both in respect to equipment and raw materials, were totally inadequate to the new needs of the country; it is satisfactory to note, therefore, that we have since increased our output to more than three times the original amount. These colors have rendered real assistance to the British dyeing industry. The enlarged production has enabled users to obtain by new methods, shades such as indigo, which they could not otherwise have obtained, and in some instances mills have been kept running by the substitution of these colors, coupled with the basic colors. Without them it would have been impossible for the country to have produced anything like the variety during the war, and it is reasonable to believe that our increased output has had a beneficial effect in checking the tendency of prices for such colors to rise to an unreasonable level. High prices have been made for some of them in small quantities, but this only tends to show the prices which these colors might have reached but for our increased output.

"Although we have been able to offer a fair supply of direct blacks, the position of a variety of direct

cotton colors has been less satisfactory, owing to the lack of some of the necessary materials, including fuming sulphuric acid. We have been more fortunate in respect to wool colors, however, the necessary brown for dyeing khaki cloth having been provided without difficulty. At one time khaki yellow became rather scarce, but for the last six or eight months the supply has been sufficient to meet the demand, and the same statement applies to khaki green. With respect to the ordinary wool colors, our supply of the fancies has been smaller than our normal deliveries, owing to the limited amount of raw materials available, but our plant for producing these and the necessary direct cotton colors has been increased with a view to taking immediate advantage of the prospective increase in the supply of intermediates.

"We are now manufacturing a color similar to tartrazine, thus checking a further rise in the price of this dyestuff and enabling us to meet the demand. Gallocyanine has also been delivered in satisfactory quantity,

and its process of manufacture will be extended to other colors resembling it.

"Increased facilities for the production of basic colors and patent blue are also planned, and before long we shall manufacture several of the vat colors in small quantities.

"I would direct special attention to the vital importance of the manufacture of the intermediate products. The products from which many dyes are made have not been manufactured in this country on a commercial scale, and a practical knowledge of the processes and plant required for obtaining the best results in respect to them can only be arrived at by investigation and experiment. A considerable amount of work of this nature has been done, and plant for the manufacture of paranitraniline and betanaphthol and other intermediate products is in course of construction. There remains, however, a large amount of work of this nature which is essential to the building up of a national industry."

Second National Exposition of Chemical Industries

Opening Exercises

The Second National Exposition of Chemical Industries, was opened at 2 p. m., Monday, Sept. 25, at the Grand Central Palace. At 2.30 the conference hall where the official opening exercises were to be held was well filled. CHAS. F. ROTH, one of the managers of the exposition, was chairman of the exercises and after a few words of welcome, he introduced the first speaker, Dr. CHAS. H. HERTY, president of the American Chemical Society.

Dr. Herty spoke in his impressive style with a great deal of enthusiasm as follows:

It is an inspiring occasion that brings us together here to-day. In this building are gathered the evidences of the resourcefulness, ingenuity and courage of American chemists and chemical engineers.

The exhibits, more than doubling in number those in the initial exposition last year, furnish ample proof that the unusual call upon the chemists during recent months has been worthily met, and it is an especial pleasure to express to the managers of the exposition our indebtedness for the splendid handling of this increasingly important event.

In addition to the important advances here evidenced in the manufacture of dyestuffs, glass, porcelain and machinery of all sorts for chemical plants, there is a distinct new feature furnished by the inclusion of exhibits of natural resources suited to the development of chemical industries.

I feel that our modest beginning along this line presages a far wider development in the future, and that this exposition will assume naturally, though gradually, its true function; namely, an assemblage of the products of chemical industry and a meeting place for consultation and discussion of manufacturing difficulties, and as an assemblage point for the exhibition of the great natural resources of this country, exhibited from the standpoint of their availability for the development of chemical industries. With this new and widened vision, untold possibilities of great national service present themselves.

The deep and intelligent public interest in the exposition furnishes abundant proof that the people of our country are steadily gaining a clearer idea of the fundamental importance of chemistry to the welfare of the nation.

While the growth of chemical industries during the past year has been marvelous, nevertheless we chemists must bear in mind that, if this growth is to reach its full fruition, co-operation along the broadest lines is absolutely necessary in all of our efforts. Germany has already publicly announced the unification of all the separate establishments of its great dyestuff industry. So, too, have we learned recently of the international co-operation between the chemists of England, France, Russia and Italy. In view of such developments, it behoves us to give the most serious consideration to the question of our policies in the development of the American chemical industry.

Under our national laws combinations are made illegal, and, in the past, the American chemical manufacturer has been characterized by a rather unusual amount of secretive-

ness regarding his operations. Surely the day has arrived for broader policies, in which the forces of this nation can harmoniously work together without sacrificing individuality to the end that the products of American chemical industry, made from our own natural resources, may not only fully supply our domestic needs but may meet in fair competition the products of all other countries in the markets of the world.

This problem of co-ordinated effort is the big problem of this week, and, in its out-working, I urge the loyal and patriotic thoughts of every chemist.

Mr. LAWRENCE ADDICKS, past president of the American Electrochemical Society was the next speaker. He spoke as follows:

It is eminently fitting that a word should be said for electrochemistry on the occasion of this exposition of progress in American chemical industry. This branch of chemistry, which had very modest beginnings on the practical side with the development of primary batteries and electro-plating, has grown so rapidly and notably upon American soil that it has had much to do with transforming old-time chemistry into the chemical engineering of to-day, which is fast taking the place held by electrical engineering in the last twenty years as the great field of opportunity. For several centuries the chance for fame and wealth lay chiefly in the exploration and conquest of new lands. Then came the great commercial ventures in shipping and commerce. As experience made this commonplace, men turned to searching out the great mineral deposits in the less known parts of the world. When gold fever died out and the world began to look monotonous, the electrical developments of the last fifty years offered just as sensational work nearer home. And now the era of chemical engineering seems to have fairly arrived.

Electrochemistry has a peculiar responsibility which differentiates it from chemistry proper in that it is the common meeting ground of several hitherto separated sciences each of which overlaps to form some of the most interesting of problems. It is here that the electrical engineer and the chemist first appreciate that the directive influence of electrical energy can not only be used to upset normal chemical affinities, but that the resulting processes offer one of the largest uses for electric power. It is here that the chemist realizes that physics is but a branch of chemistry and the physicist that chemistry is but a branch of physics. Metallurgy finds not alone new tools, but new products. Medicine becomes interested in radioactivity, and, I am sorry to say, law in electrochemical corrosion. In this way electrochemistry has exercised a reuniting influence upon the schisms which have resulted from specialism. In the same way the American Electrochemical Society has brought together men from widely different fields of effort and it is only by breaking down the barriers between science and engineering and creating a compact and comprehensive profession of the entire engineering fraternity that progress in any way commensurate with present opportunity can be made.

The rapid developments of the last year have, of course,

largely been due to the abnormal conditions affecting foreign commerce. Some of our exports have been in great demand, while some of our imports have been absolutely cut off. This has resulted in high values for both classes of materials, giving the needed stimulus for the development of substitutes and the founding of many new industries. And the market is not simply a temporary one, dependent upon war-time conditions. In many cases the investment required has been the only deterrent heretofore; now the investment has been made. Also a product never goes to an abnormal price without permanently losing some fields of application. For example, the high price of copper has surrendered many brass articles to enameled or brass plated iron; in other cases parts, such as ship hardware, have been greatly lightened. Sodium is replacing potassium wherever possible, as in glass, etc., and so on. Then again the actual shortage in certain products has developed processes for refining low-grade material, a notable case being that of electrolytic zinc. These changes are permanent and we find ourselves suddenly carried forward through ten or fifteen years of normal progress in many lines of industrial endeavor, and, what is more, every part of this progress from the scientific research upon which it is based to the source from which the raw material is drawn is American.

The international situation in which we find ourselves has also caused a great awakening throughout the country as to the need of the co-ordination of our industrial resources for national defense, and this has done much toward a mutual understanding in a country where the pendulum has generally swung between bitter competition and monopoly, between which extremes there is little to choose.

We may regard this exposition and the concurrent meeting of three professional societies not only as a demonstration of the accomplishments of the last two years, but as an earnest of what can yet be done.

It is with especial pleasure, therefore, that the Electrochemical Society does its small share in welcoming you to this Exposition of Chemical Industries, which shows what united effort is doing to put this nation at the very front in chemical engineering.

Mr. THOMAS J. KEENAN, secretary of the Technical Section of the Paper and Pulp Association reviewed the progress which has been made in the manufacture of paper during the last fifteen years. He said that the latest census showed the paper industry to be second in importance only to the iron and steel industry. The total invested capital is \$500,000,000, while the value of the annually manufactured products of pulp and paper amounts to \$350,000,000. He showed how important chemistry was to the art of paper making. Promising developments in the southern states, through the application of chemistry to the recovery of paper fibers from waste wood, should be mentioned. Kraft paper is now made from imported pulp to the amount of some 60,000 tons annually. Immense quantities of yellow pine waste lumber are available in Florida, Georgia, Louisiana, and other southern states for the manufacture of pulp by the sulphate process, which yields the strong brown paper called 'kraft.' A beginning in the development of this industry has been made in the South, and it is expected to make us independent of other countries so far as this class of paper is concerned.

Dr. IRA REMSEN of Johns Hopkins University said that he had devoted his life to the science of chemistry but had always been profoundly interested in industrial chemistry. He said that the advancement of industrial chemistry depended upon the advancement of the science of chemistry and that therefore there should be the closest co-operation between the scientists and the industries.

Mr. ADRIAAN NAGELVOORT, one of the exposition managers closed the exercises with a few words about the exposition and with a hearty welcome to the visitors.

The exposition itself was an immense success. It was again managed by Mr. Adrian Nagelvoort and Mr. Charles F. Roth, jointly with the International Exposition Co., with Mr. F. W. Payne at the head.

While last year all the exposition was on the ground floor, it was necessary this time to use also the second

floor. The exposition had practically doubled within a year—in itself a suggestive indication of the rapid progress of American chemical industries. The adjoining illustrations will give an idea of the attractiveness and comprehensiveness of the exhibits. An alphabetical list of the various exhibitors and their chief exhibits follows:

Paul O. Abbé, New York City, exhibited mixers, jar mills, rotary cutting machine, combined sifter and mixer for dry powder, respirators and goggles. Of especial interest was a new mill consisting of 4 small jars and 2 large jars. The small jars run at a higher speed than the large ones. Mr. Abbé was in charge.

Abbé Engineering Co., New York City, exhibited small jar and ball mills in actual operation; a working model of their tube mill with patent "Ideal" spiral feed and discharge with glass end to show method of operation; section of pebble mill showing patent manhole frame with detachable flanges which permits replacing lining plates without calling for new manhole frame. Mr. Henry Kleinfeld was in charge.

H. Reeve Angel & Co., New York City, exhibited their full line of filter papers. Mr. Brothers and Mr. Lenton were in charge.

Alberene Stone Co., New York City, exhibited a complete laboratory installation of bench, gas hood, and sink made of Alberene stone, and samples of the stone cut to various sizes and shapes. Also soap stone linings for pulp furnaces. Photographs of various installations. Messrs. N. N. Moneypenny and A. Y. Meeker were in charge.

American Apparatus Corporation, New York City, had a very complete exhibit of general laboratory supplies, among which were Riche Adiabatic Calorimeters, Lenzman Insol glassware, quartz glass, testing machines, vacuum pumps, laboratory furniture, water stills, etc. Of especial interest was a large glass flask of about 50 gals. capacity with walls less than one-sixteenth inch thick. Mr. G. Gruenberg was in charge.

American Chemical Society:—Booth for the use of visitors.

American Coal & By-Products Coke Co., Chicago, Ill.—Diagrammatic drawings in colors of the Roberts method of destructive distillation of coals and method of recovery of by-products, model of flueless oven, type of wall brick, illustrations of by-product apparatus for the recovery of cyanogen, benzol and the light oil homologues, samples of products recovered. Messrs. Arthur Roberts, H. V. Patterson, and Louis C. Whiton in charge.

American Electrochemical Society displayed an automobile chassis with a dismantled engine showing by means of placards attached to the points in question, what a large part electrochemistry played in its manufacture. "Niagara made Detroit possible." The idea of the exhibit was Mr. Lidbury's. Dr. Schluederberg and Dr. Fink were in charge.

American Institute of Mining Engineers had a booth for the entertainment of visitors.

American Synthetic Color Co., Inc., Stamford, Conn., exhibited intermediates such as phenol, resorcinol, paranitrochlor, orthonitrochlor, nigrosine, and others. Mr. C. H. Hazard was in charge.

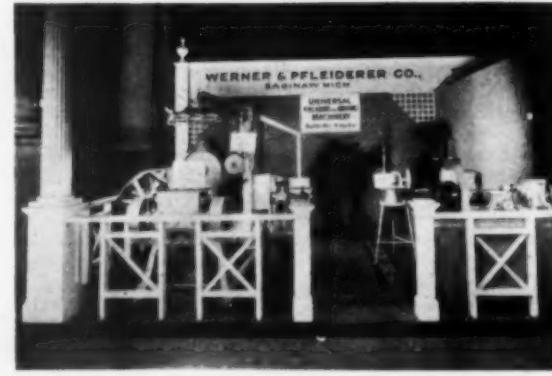
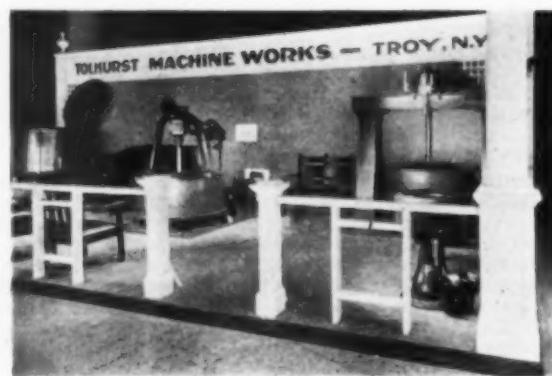
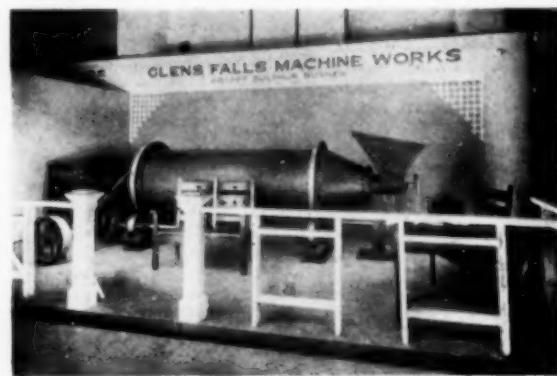
American Transformer Co., Newark, N. J., had an exhibit in conjunction with that of the Research Corporation. They supplied the 100,000-volt transformer for the demonstration of the Cottrell electrical precipitation process. Mr. W. F. Hubley was in charge.

Arnold, Hoffman & Co., New York City, showed the alkaline products of Mathieson Alkali Works, Castner Electrolytic Alkali Works, and Nitrogen Products Co., for which they are the selling agents. They also exhibited the Wallace & Tiernan automatic chlorinator. Messrs. H. H. Hall, A. L. Hays, and J. E. Clancey were in charge.

E. B. Badger & Sons, Boston, Mass., had an exhibit showing drawings and diagrams of their distillation apparatus and Badger-Webre evaporators. Displayed a few pieces of the beaten copper work. Mr. C. L. Campbell was in charge.

J. T. Baker Chemical Co., Phillipsburg, N. J., had an attractive exhibit of Baker's analyzed chemicals neatly arranged in show cases, among which were PCl_3 , PCl_5 , POCO_3 , molybdic acid and ammonium molybdate. Mr. E. C. Baker was in charge.

City of Baltimore, Md., exhibited a miniature reproduction of the city of Baltimore showing harbor and dock facilities, also several photographs of conditions pertaining to feasibility of plant location in that city. Mr. H. Kent McKay was in charge.



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Barber Asphalt Paving Co., Philadelphia, Pa., exhibited a very complete line of preservatives among which were their "Genasco" acid-proof paint, "Genasco" metal preservative, Vulcanite acid-proof mastic, and various types of waterproofing and roofing materials. A demonstration was made of the colloidal aspect of Trinidad asphalt with special attention to the colloidal mineral matter of same. Mr. H. M. Menner was in charge.

The Barrett Company, New York City:—Refined coal tar derivatives and other products manufactured by various companies in which their chemicals had been used. Messrs. H. G. Sidebottom, F. E. Dodge and W. E. Brophy were in charge.

Bausch & Lomb Optical Co., New York City, exhibited their metallurgical microscopes and metallographic instruments, and their Made-in-America optical glass. Messrs. R. C. Dean and A. E. Welti were in charge.

Beach-Russ Company, New York City, showed small sizes of their rotary vacuum pumps and pressure blowers in operation. Their compound dry vacuum pump is guaranteed to produce a vacuum within one-tenth inch of barometer, which was demonstrated by means of a colored water column 34 feet high graduated for both water and mercury readings. Messrs. C. A. Beach, H. C. Russ and J. Buckley were in charge.

W. Becker's Aniline & Chemical Works, Brooklyn, N. Y.:—A very interesting exhibit showing many articles of various materials that had been colored with their American-made aniline dyes. They also showed their dyes and intermediates in the various stages of the process of production. Messrs. Becker, Miller and Drobegg were in charge.

Bethlehem Foundry & Machine Co., So. Bethlehem, Pa., exhibited several pieces of machinery made of "Tantiron" for manufacture of acids. A fume pipe weighing about 3600 lb. attracted attention. Messrs. W. A. Wilbur, G. J. Lehman and R. E. Wilbur were in charge.

The Bristol Company, Waterbury, Conn.:—Complete line of temperature recording apparatus, pressure and vacuum gauges, and heat regulating instruments, of both indicating and recording types. Special attention was given to their new automatic temperature compensator for the cold ends of pyrometer thermo-couples, and their new continuous flow wet and dry bulb recording thermometer. Mr. H. W. Moss was in charge.

Brown Instrument Co., Philadelphia, Pa., exhibited their stationary and portable electric pyrometers, of indicating and recording types, and also automatic heat-control for furnaces, retorts, etc., and recording thermometers, both of which are new lines with this company. Messrs. Goheen, Andrews and Murray were in charge.

The Buffalo Foundry and Machine Company had the most elaborate and comprehensive exhibit, covering the whole west front of the main floor and occupying 1920 sq. ft. The total weight of the apparatus shown was about 200,000 lb. The principal pieces of apparatus shown were: A Nitritator weighing 24,000 lb. and of 1600-gal. capacity with closed end cooling tubes and water jacketed sides and bottom; a Caustic Pot of 2500-gal. capacity, 10 ft. 4 in. diameter and weighing 26,000 lb.; a Sulphonator, cast-iron jacketed, 700-gal. capacity; an Evaporator, 8 ft. diameter; a Vacuum Drum Dryer in operation reducing Sulphite waste liquor containing 50 per cent moisture to a dry powder (motor driven). This required installing a steam boiler and water and sewerage connection. A Surface Condenser in operation; a Dry Vacuum Pump, two-stage type, motor driven; a Vacuum Shelf Dryer; a Fusion Kettle equipped with stirring device, 600-gal. capacity; a Crystallizing Pan used in manufacturing Ammonium Nitrate, 6 ft. diameter; an Autoclave, 200-gal. capacity with jacket and designed for 1000-lb. working pressure; also another laboratory size Autoclave, gas heated; a Nitric Acid Retort and Condensing System, 9 ft. diameter, 14 ft. high, weighing about 14 tons. An illuminated transparency of their plant and products was also shown. Many of the pieces of apparatus were of a size up to the transportation facilities of the railroad. The entire display was more on a basis of a permanent exhibit such as used in a World's Fair rather than for a six-day exhibit. Mr. H. D. Miles, president of the company, was in attendance all through the week. Mr. E. G. Rippel, sales manager, who arranged the attractive display, was also in constant attendance with a large staff of engineers.

Butterworth-Judson Corporation, New York City, exhibited a line of heavy chemicals, iron ores, and their by-products, and the coal tar products of the American Synthetic Dyes, Inc. Messrs. E. E. Dougherty and M. L. Hamlin were in charge.

Carborundum Co., Niagara Falls, N. Y.:—Of particular interest to chemists was their exhibit of refractory articles such as pyrometer tubes, resistance rods, fire-bricks and muffles. They also displayed a very complete line of abrasives. The booth was in charge of Mr. Roy Lincoln.

Carolina, Clinchfield & Ohio Ry., Johnson City, Tenn., exhibited products of manufactures and natural resources located along their line. Mr. V. V. Kelsey was in charge.

Carrier Engineering Co., New York City, exhibited complete apparatus in operation for cooling about 4000 cu. ft. of air per minute 10 deg. The air was washed and cooled by water spray, but no dampness was noticed in effluent air. The cooling effect was due entirely to evaporation. An automatic humidity regulator on the booth post controlled the humidity of the discharged air by controlling the volume of air delivery. Mr. J. I. Lyle was in charge.

Celluloid Zapon Co., New York City:—Lacquer enamels, lacquers, nitrocellulose and an extensive display of different applications of "Zapon." Included in this booth was an exhibit of the Zapon Leather Cloth Co. Mr. N. E. Dabolt was in charge.

The Central Foundry Co., New York City, exhibited its "Universal" cast-iron pipe with machined joint. On account of the tight fit this joint does not need calking. Mr. R. W. Courow in charge.

Chemical Catalog Co., New York City, showed a dummy illustrating the nature of its directory of chemical apparatus manufacturers which is now on the press. Mr. F. M. Turner was in charge.

Chemists' Club, New York City:—Booth for the use of visitors.

Chemical Company of America, New York City:—Coal tar intermediates, toluidene, xylylene, benzidine sulphate, dimethylaniline and aniline. Messrs. C. Kendall and C. Christ were in charge.

Coatsville Boiler Works, New York City:—Samples of materials used in the construction of their tanks, boilers, etc. Also photographs of installations of their equipment.

E. J. Codd Co., Baltimore, Md., exhibited its chain screen door for various furnaces—metal, chemical, glass, etc. It is claimed that this door is just as effective as a solid door in keeping the heat in and the cold out. Mr. H. H. Wiegand was in charge.

Condensite Co. of America, Bloomfield, N. J.:—A very interesting exhibit showing the various uses for Condensite and Halowax. Condensite is mainly used as an electrical insulator. It has been recently tried as a substitute for the metals in printing plates, and has shown fine results. Halowax is used for electrical condensers on account of its high specific inductive capacity. Both are synthetic products. Mr. Sanford Brown was in charge.

Contact Process Co., Buffalo, N. Y., showed its products, such as sulphuric acid, muriatic acid, nitric acid, oleum, salt cake and nitre cake. The "oleum 50 per cent" attracted much attention on account of its high strength. Mr. E. R. Henderson was in charge.

Corning Glass Works, Corning, N. Y., showed a very complete line of glassware for all fields, such as their "Pyrex" brands of both chemical and oven ware, and lantern glasses, optical glasses, lenses, battery jars, bulbs, tubing and their various light filters. Mr. I. B. Cary was in charge.

Corn Products Refining Co., New York City, showed samples of various corn products. Messrs. T. J. Donnelly and G. M. McNider were in charge.

The J. H. Day Co., Cincinnati, Ohio:—A line of dry powder mixers, mixers for liquid and pasty materials, sifters. Represented by Mr. R. W. Wallace.

De Laval Separator Co., New York City, exhibited several types of centrifugal separators and clarifiers and filters.

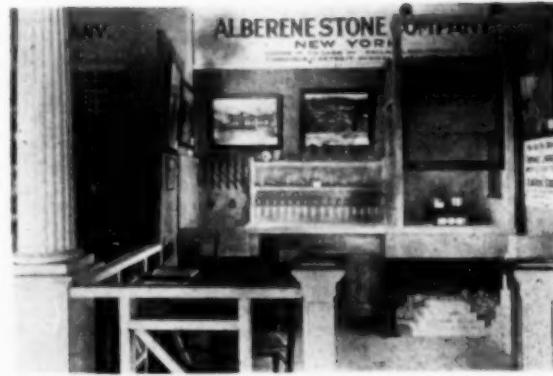
Denver Fire Clay Co., Denver, Col., showed a line of crucibles, muffles, scorifiers and cupels for the clay end of the company. In the machinery class the company exhibited Case disk pulverizer, crusher, cupel machine and laboratory flotation machine, and oil-fired tilting crucible furnace, assay and melting furnaces. Mr. W. W. Case, Jr., was in charge.

Detroit Range Boiler Co., Detroit, Mich.:—"Perfect" metal bilge-barrel with full removable head; also barrels with full draining bung; Detroit drums. Mr. W. B. Goddard in charge.

J. P. Devine Co., Buffalo, N. Y., had a very interesting booth, inasmuch as it exhibited the first vacuum double-drum dryer for American practice. This particular piece of machinery was built especially for the exposition. The company also exhibited one of its 1000-lb.-pressure auto-claves. Messrs. Joseph P. Devine, F. Howard Mason and Nathan Owitz were in charge.

Dorr Company, New York City, exhibited a working model of a three-deck washing classifier, showing its application to fine granular materials. Silica sand and indigo were used in the demonstration. The company also showed models of thickeners or dewaterers, and agitators or mixers. Messrs. H. N. Spicer, Howard Morgan, N. Cunningham, R. Shafor and F. F. Peters were in charge.

The Dow Chemical Co., Midland, Mich.:—Organic chlorine and bromide compounds, synthetic indigo and dye inter-



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mediates. Messrs. A. E. Converse, H. H. Dow, James T. Pardee, W. H. Van Winckel and J. L. Camp in attendance.

Dowington Manufacturing Co., East Dowington, Pa., displayed a small working model in operation of the Miller patent duplex beater for paper pulp, and also a small beater for laboratory purposes. Showed yellow-pine products of the Empire Chemical Company that had been recovered by the Clope process. Messrs. Guyon Williams, C. L. Ellis and Jacob Edge were in charge.

Driver-Harris Wire Co., Harrison, N. J., had a very attractive booth, part of which was fitted up to resemole a heat-treating furnace in operation. In the "red-hot" interior could be seen one of the company's "Nichrome" carburizing boxes. The company also exhibited wire mesh baskets, trays, woven and cast containers for cyanide baths and heat-treating. Mr. S. M. Tracy was in charge.

E. I. Du Pont, De Nemours & Co., Wilmington, Del., showed samples of their various products, among which were bronze powders, pyroxiline solutions and intermediates. Their various split-leather solutions were shown by samples of rough split leather. An exhibit of Fabricoid, a substitute for leather, was also included, as were also the rubber-coated fabrics of the Fairfield Rubber Co. Mr. R. L. Vilas was in charge.

Duriron Castings Co., New York City, showed a varied line of acid, alkali and rust proof castings, including centrifugal pumps operating with a storage tank, also various standard pipes, fittings, plug cocks and globe valves. Of especial interest were the two types of the Hough nitric-acid condenser, one with Duriron tubes and the other with glass tubes. Messrs. J. W. Pitman, F. W. Kolb, J. S. Miller, Jr., and R. F. Schmidt were in charge.

Eimer & Amend, New York City, exhibited a great many of their laboratory supplies, consisting to a large extent of American-made apparatus, among which were the Fleming carbon-combustion apparatus, Emerson carbon-combustion train, Brinell meter, Gramercy constant-pressure blowers, Barnstead water still, Freas constant-temperature electric ovens, Veit electrolytic apparatus, Emerson adiabatic calorimeter, Ziess optical goods, Pyrex and Frye laboratory glassware, Coors porcelain ware and a full line of replaceable unit electric furnaces. Messrs. E. Child and T. M. Saulter were in charge.

Thos. A. Edison, Orange, N. J.:—Benzol, toluol, xylol and numerous other coal tar products. A motor-truck size of his alkaline battery, showing the nickel flake, nickel hydroxide and iron oxide, attracted considerable attention. Mr. W. Mallory was in charge.

Electro Bleaching Gas Co., New York City:—Showed a varied line of fabrics that had been bleached with Liquid Chlorine. Also exhibited some of their chlorinating apparatus, and a full line of alkalies, of particular importance caustic potash, manufactured by the Niagara Alkali Company. Messrs. Thos. W. Pritchard, J. R. Kienle, Chas. S. Sawyer, and J. R. MacMillan were in charge.

The Electro-Chemical Co., Dayton, Ohio:—Passage type electrolytic cell, intermittent type electrolytic cell, finished and unfinished bleached products of paper and textile mills. Represented by Messrs. J. R. Pfeifer and John Gerstle.

Electrolytic Zinc Co., Inc., New York City:—Samples of electrolytic zinc. Mr. A. W. Hahn was in charge.

Electron Chemical Co., Portland, Maine, exhibited photographs of installations of Allen-Moore electrolytic cells in commercial practice of their design. They hold the patent rights for this cell. Mr. H. I. Allen was in charge.

Elyria Enamelled Products Co., Elyria, Ohio, exhibited a large glass-lined nitrating kettle with new design removable jacket. Demonstration of thorough mixing by off-centre and side agitation; showing of new glass-enamelled evaporating pan with cast-iron instead of steel base. The durability of this glass-enamelled ware was demonstrated by causing a sudden change of about 500° F. in it without any resulting sign of fracture. Represented by Messrs. W. E. Gray, J. O. K. White, R. F. Goecke, E. P. Post, E. H. Haserot and W. E. Gray, Jr.

The Fabra Company, Ltd., New York City:—Mr. W. A. Brassard was on hand to enlighten those who contemplated exporting chemicals to England.

Foote Mineral Co., Philadelphia, Pa.:—Exhibit of unusual ores and minerals including zirconia ore. Refractory bricks, zirconia ware (zirkite), zirconia silicate, zirkite cement, all made from zirconia ore, formed an important part of their display. A stereopticon machine showed pictures of their new American monazite deposit, and a complete line of tungsten ore and tungsten products were also of particular interest. Messrs. H. C. Meyer and Edw. Foster were in charge.

The Foxboro Co., New York City, exhibited a complete line of indicating and recording instruments for tempera-

ture, pressure, speed, time, flow, humidity, and temperature control. Messrs. W. W. Patrick, H. B. Bernard, and C. E. Sullivan were in charge.

Franco-Swiss Colours Co., New York City:—Coal tar colors. Had a demonstration of dyeing to show the fastness, strength and quality of their colors. Mr. W. V. N. Powellson was in charge.

Freeport Sulphur Co., New York City, exhibited sulphur in native and refined states. Mr. S. L. Parsons, Jr., was in charge.

Chas. F. Garrigues Co., New York City, exhibited samples of chemicals used in the manufacture of explosives, and Draper Manufacturing Company's steel barrels. Mr. Alfred Varian, Jr., was in charge.

Geissinger Regulator Co., New York City:—Demonstration of the Geissinger industrial temperature-control system for all classes of heat-control work, such as conveyer type ovens, large flue dampers in superheaters, etc. Mr. H. W. F. Threse was in charge.

General Bakelite Co., New York City, exhibited various products, mostly for use as electrical insulators, made from Bakelite. A new application has been made possible by the advent of a process for coloring Bakelite to harmonize with Circassian walnut, mahogany, etc. One manufacturer is now using it for knobs on dental chairs. Another new application of Bakelite is in impregnating sheets of canvas, which are later pressed together, for the manufacture of noiseless gears and pinions. Mr. H. S. May was in charge.

General Chemical Co., New York City, displayed their own line of heavy chemicals and had space for the following subsidiaries: Baker and Adamson, N. Y. C., standard C. P. acids and salts for laboratory use, and dye intermediates. Benzol Products Co., N. Y. C., aniline salt, nitro benzol oil, and dye intermediates. Ryton Baking Powder Co., N. Y. C., baking powder. Messrs. J. E. Wilson, Geo. Vardy, and R. W. Mitchell were in charge.

General Electric Co., Schenectady, N. Y., did not attempt to display any equipment but had Mr. W. O. Jones and others on hand to answer any inquiries.

German-American Stoneware Works, New York City, exhibited a very complete line of chemical stoneware, ranging in size from small tower fillings to a 528-gallon storage vessel, including valves, mixing bottles, tourills, and automatic acid eggs. Of especial interest was a centrifugal pump, and an exhauster which had been tested up to 4500 r.p.m. Messrs. Percy Kingsbury and B. S. Cameron were in charge.

Glens Falls Machine Co., Glens Falls, N. Y., exhibited their standard 36-inch Tromblee & Paull rotary sulphur burner of which they are the sole manufacturers. Mr. Fred B. Chappell was in charge.

Golden Chest Mine, New York City:—A high grade tungsten ore from the Golden Chest Mine at Murray, Idaho. Mr. Vivian Green was in charge.

Great Western Power Co., San Francisco, Cal.:—Data and photographs relative to the hydro-electric developments and possibilities of electrochemical industries on the Pacific Coast. Mr. J. W. Beckman was in charge.

Emil Greiner Co., New York City, exhibited glassware and miscellaneous laboratory supplies, including different types of apparatus for gasometric determination of which the DuPont nitrometer was of particular interest. Mr. M. F. Kraissl was in charge.

Hardinge-Conical Mill Co., New York City:—Complete working model of the Hardinge Mill with glass arranged so that the inside workings could be seen. This is a continuous feed and discharge grinding machine. Samples of materials ground and unground. An automatic stereopticon showed pictures of various installations. Mr. R. Clark was in charge.

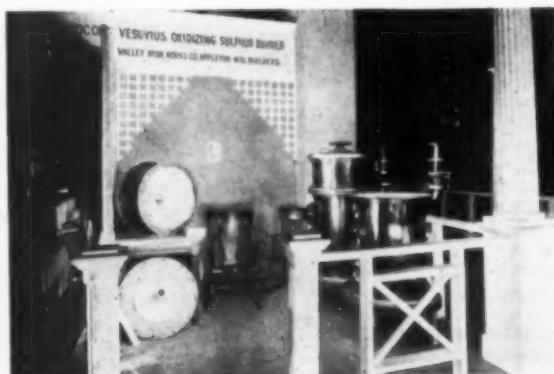
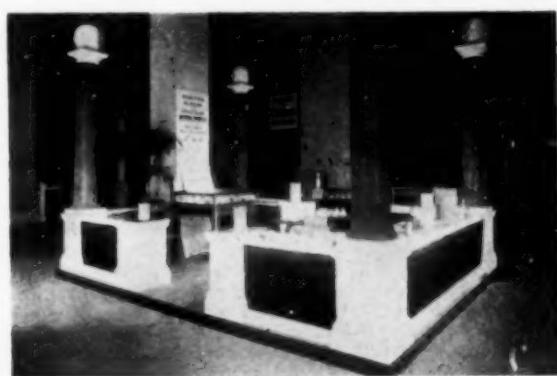
Harrison Bros. & Co., Phila., Pa., exhibited chemicals used in the manufacture of pigments, dyes and paints for fireworks, red danger lights, textiles, linoleums, etc. Mr. P. Garrod was in charge.

S. F. Hayward & Company, New York City, showed a line of safety appliances, including respirators, gas masks, helmets and goggles. Mr. Pratt was in charge.

Frank Hemingway, Inc., New York City, exhibited a line of coal tar derivatives, manufactured and imported. A stenographer was present for the convenience of the visitor and Mr. H. Dixon was on hand to answer any questions propounded.

Herold China & Pottery Co., Golden, Colo., showed a line of Coors chemical and scientific porcelain, of which they are the manufacturers. Mr. C. F. Quaintance was in charge.

Herman A. Holz, New York City, showed samples of the application of Rhotanium as a substitute for platinum; Beighlee pyrometer equipment and portable Brinell meters. Mr. Holz was in charge.



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Hooker Electrochemical Co., New York City, exhibited its electrochemical products.

Huff Electrostatic Separator Co., Boston, Mass.:—Small working model of the Huff separator which uses 12 to 28,000 volts on ore separation, and a small model of the Plumb pneumatic jig for ore separation. These are both dry processes. Mr. H. B. Johnson was in charge.

F. C. Huyck & Sons, Albany, N. Y.:—Samples of their woven woolen filter cloths and "Kenwood" felts. Messrs. F. J. McGovern, W. A. Yule and D. C. Jordan were in charge.

Industrial Filtration Corporation, New York City, showed a rotary continuous vacuum filter and its removable leaf or cell type vacuum filter. This latter consisted of two tanks with an overhead traveling set of filter plates provided with suction line. This set of plates could be transferred from one tank to the other by washing after forming the coke in the first tank. Messrs. W. H. Harding, Jr., and H. B. Faber were in charge.

International Equipment Co., Boston, Mass.:—Display of laboratory centrifuges for experimental and analytical purposes, for textile industry, and for chemicals. Mr. Arthur Kendrick was in charge.

International Glass Co., Millville, N. J.—Complete line of glass tubing, chemical apparatus and laboratory glassware, featuring their American-made Insol beakers and flasks. Mr. Paul O. E. Frederick was in charge.

Kieselguhr Co. of America, New York City, demonstrated its well-known torch test on a brick of "Sil-O-Cel." An automatic stereopticon machine showed detailed illustrations of various installations to which this heat insulating product has been adapted. Another product of Celite that they showed was "Filter-Cel" for use in filtration. Celite is also used in "bulking" products. Messrs. P. A. Boeck, A. H. Krieger and D. S. Collins were in charge.

F. Kleinschmidt & Company, Buffalo, N. Y., had on exhibition one of their small self-cleaning, rotary evaporators. Mr. D. H. Kleinschmidt was in charge.

A. Klipstein & Co., New York City:—Coal tar products; sulphur black, blue and green; sulphurated oils; varnish gums; and tanning material of which their "Oxi-tan" came in for most attention. Mr. E. C. Klipstein was in charge.

H. Koppers Co., Pittsburgh, Pa., showed a model of a by-product coke oven. Also samples of coke made from coals from various States, primary coal-tar derivatives, and various photographs of plants constructed by them. Mr. H. B. Kirkpatrick was in charge.

L. O. Koven & Brother, Jersey City, N. J., exhibited their Kelly filter in conjunction with Dr. Emil E. Lungwitz.

The Laboratory Supply Co., Columbus, Ohio:—Complete line of Ohio Pottery Co.'s "Circle S" chemical porcelain, complete line of "Solno" chemical glassware. "Circle S" filter paper, microscopic slides. Represented by Messrs. Robert Carl Schroth, Jr., C. L. Schroth and C. D. Fraunfelter.

Lead Lined Iron Pipe Co., Wakefield, Mass., exhibited lead lined valves and pipe fittings. A feature of their exhibit was a sample of a sixteen-inch lead lined pipe. Mr. S. H. DuBois was in charge.

Leeds & Northrup Co., Philadelphia, Pa., exhibited a complete line of apparatus for measuring conductivity of electrolytes; electrometric titration apparatus for determination of chromium and vanadium in steel and other alloys; indicating and recording pyrometers; and hydrogen ion apparatus, which is a new line they are exploiting. Mr. C. S. Redding was in charge.

Lehigh Car, Wheel and Axle Works, New York City:—Gray charcoal iron castings, sprocket wheels, car wheels, "Titanite" lining for grinding machinery. Model of the Fuller-Lehigh pulverizer. Space in this booth was also used by the Lehigh Foundry Company, Fullerton, Pa., acid resisting castings; the Lehigh Stoker Co., Fullerton, Pa., and the Fuller Engineering Co., Allentown, Pa., who specialize in the design and construction of grinding plants. Messrs. C. R. Rinehart, L. A. Salade, Bernard Enright, Edward Fromm, and W. A. Stubblefield were in charge.

Life-Saving Devices Co., New York City:—Demonstration of the operating principles of their "Lungmotor." Mr. S. N. Fowler in charge.

Arthur D. Little, Inc., Boston, Mass.—Showed interesting blue-prints of some of the industrial plants they have designed. Mr. H. S. Skinner was in charge.

Emil E. Lungwitz, New York City, exhibited the Kelly filter press in conjunction with L. O. Koven & Brother. This was the 450 sq. ft. size filter of which all the features could be examined. Dr. Lungwitz was in charge.

Luzerne Rubber Co., Trenton, N. J., exhibited various articles made in hard rubber to resist chemicals such as pipe and pipe fittings, acid buckets, color boxes, check valve bowls, funnels, etc. Mr. W. L. Royall was in charge.

Madero Brothers, Inc., New York City:—Exporters of chemicals.

Marden, Orth & Hastings, New York City, had their booth very nicely equipped with wall cabinets containing yarns of wool, silk and cotton showing the great variety of colors secured from their wood and aniline dyes. Samples of chemicals, oils, etc., manufactured in their plant were also displayed. Mr. H. G. McKerrow was in charge.

Merck & Co., New York City, exhibited a shelf of their well-known "Blue Label" reagents, and large jars of hydroquinone (American-made), synthetic carbolic acid, pure benzol, aniline oil and other products. Messrs. G. H. Copeland, O. S. Putnam and R. L. Lauber were in charge.

Metallurgical and Chemical Engineering, New York City, placed its booth at the disposal of visitors and exhibitors with respect to telephones, clerical and stenographic service. Mr. Hays was in charge. Messrs. Muir, Bedell, Munn, Rogers, Cain, Bergen, Crimmins, and Soltau were in attendance.

Metals Disintegrating Co., New York City, showed samples of their powdered magnesium, lead, tin, zinc, and aluminium. Mr. A. W. Hahn was in charge.

Mine & Smelter Supply Co., New York City:—Lindsay oil furnace, Colorado clay products, Samson laboratory crusher, McCool pulverizer, Redwood pipe and, of particular interest, Heusser analytical and assay balances, with patent pan extractor and multiple weight attachment. Mr. J. S. Shedd was in charge.

Mississippi River Power Co., Keokuk, Iowa:—Views of plant and equipment, maps of power zone. Represented by Mr. Norman T. Wilcox.

Monsanto Chemical Co., St. Louis, Mo., displayed the following chemicals: Acetanilid, acetophenetidin, caffeine, chloral hydrate, conmarin, glycerophosphates, phenol (U. S. P.), phenolphthalein, saccharin and vanillin. Mr. B. M. Covault in charge.

J. L. Mott Iron Works, New York City, showed cast-iron, steam-jacketed and porcelain-lined mixers and kettles. Mr. R. H. Horne was in charge.

Multi-Metal Separating Screen Co., New York City:—Screens in bronze, brass, copper, nickel and Monel metal for filtering and sifting. Also a line of safety devices, including hoods, masks, respirators and goggles. Messrs. F. Stern and S. Stern were in charge.

Nash Engineering Co., South Norwalk, Conn., exhibited a hydro-turbine wet vacuum pump in actual operation, with means for obtaining the horsepower of the pump by measuring the reaction of the motor frame, which was hung on ball bearings, and the quantity of air handled by orifice and mercury gage. An unassembled standard hydro-turbine showed the interior details. The company's line of Xyloform products in the forms of paint, varnish, egg preservatives and grease-proofing compound for paper were also shown. Mr. I. S. Jennings was in charge.

National Aniline & Chemical Co., New York City, exhibited the Schoellkopf aniline dyes. Dr. Watkins was in charge.

National Gum & Mica Co., New York City:—Dye-wood extracts, carbon bisulphide and Mikah cold glues. Dr. Jerome Alexander in charge.

City of Newark, N. J.:—Maps and photographs of Port Newark Terminal. Mr. J. C. Hallock was in charge.

Newport Chemical Works, Inc., New York City, exhibited "Newport" rosin. The quality and transparency of this product were well shown by placing a high-powered light behind a layer of it. Mr. J. R. M. Klotz in charge. Messrs. Cranz, Turner, Burd and Mackie were present.

Norton Company, Worcester, Mass.:—Exhibit of "Alundum" crucibles, tubes, etc., for carbon determination and various other refractory apparatus of Alundum and Crys-tolon. A demonstration was made of the porosity of Alundum by constantly passing a liquid through a crucible of this material. The columns at the corners of the booth were coated with Crys-tolon. Mr. P. G. Savage was in charge.

The Palo Company, New York City:—Extensive line of chemical and metallurgical apparatus—Irite pyrometers, gas-testing apparatus, spectrometers, etc. Dr. F. Rohde and Messrs. B. A. Foley and Schaefer were in charge.

Patterson-Allen Engineering Co., New York City, exhibited its lead-lined, alloyed and plain "Everlasting" valve in sizes from $\frac{1}{4}$ in. to 24 in. Mr. C. Davey was in charge.

Pennsylvania Salt Mfg. Co., Philadelphia, Pa., showed quite an extensive line of products in which its products are used, also samples of its acids, salts and other chemicals. Of particular interest to the visitors were the many shapes in which some of the salts were shown—crystal lettering, crystal basket, solid barrel of aluminium sulphate and a chessboard made of Greenland kryolite. Mr. C. A. Hall was in charge.



Exhibits at Second National Exposition of Chemical Industries

The Pflauder Company, Rochester, N. Y., had an exhibit showing various glass-enameded steel tanks and other apparatus, including a one-piece tank, a steam-jacketed mixing tank for nitration purposes; also rubber and lead lined tanks. Mr. F. L. Cradock was in charge.

Pittsburgh Testing Laboratory, Pittsburgh, Pa., exhibited some of its chemical products and reports to show the scope of what it does.

Precision Instrument Co., Detroit, Mich.:—One 3-in-1 gage registering forced draft, combustion chamber vacuum and last-pass vacuum, showing differentials through the boiler and through fuel bed, differential pressure gage for low reading, line of CO_2 recorders, orsat and recording gages. Mr. A. T. Baldwin in charge.

Prest-o-Lite Co., Inc., Indianapolis, Ind., exhibited bunsen burners, lead-burning equipment, soldering, brazing, welding and cutting torches, and various sizes of its storage battery. Mr. M. J. Ryan in charge.

Process Engineers, Ltd., Montreal, Que.:—Rosin sizing process for paper mills. Messrs. J. A. De Cew, H. A. Radford and R. B. Bert were in charge.

The Product Sales Co., Baltimore, Md., exhibited kaolin, feldspar and quartz.

Pyroelectric Instrument Co., Trenton, N. J., featured the "Pyrovolt" pyrometer. Also showed electric furnaces, adapter boxes and resistance cubes. Dr. E. F. Northrup and Messrs. Dudley Willcox and H. F. Porter were in charge.

Raritan Copper Works, Perth Amboy, N. J., exhibited ingots and wire bars of "Anaconda" electrolytic copper and "N. E. C." electrolytic zinc; also showed nickel sulphate and copper sulphate recovered; selenium in various forms, tellurium, and gold and silver bars. Mr. S. Skowronski was in charge.

Raymond Bros. Impact Pulverizer Co., Chicago, Ill.:—Samples of over 100 different air-floated products reduced by Raymond Mills in chemical and industrial institutions; also detailed illustrations of principal machines and drawings of installations. Messrs. C. M. Laurezen, William B. Senseman, W. M. Cook and Samuel B. Kanowitz in attendance.

Research Corporation, New York City, showed a small working model of the Cottrell electrical precipitation process for removing dust from gases. Frequent demonstrations were given and attracted a great deal of attention. The voltage used was about 40,000, whereas in actual practice up to 100,000 is used. Messrs. Linn Bradley, A. F. Meston, P. E. Landolt and H. D. Egbert were in charge.

Richmond Waterproof Products Co., New York City, exhibited waterproof cements for cementing parquets and linoleums to concrete. Messrs. George T. Simonson, J. J. Wilson and A. Falstrault were in charge.

Roessler & Hasslacher Chemical Co., New York City, exhibited metal cyanides and "Trisalys" for electroplating, and other chemicals.

Ruggles Coles Engineering Co., New York City, exhibited a working model of their class A double shell direct heat type dryer. Mr. F. E. Fitch was in charge.

Schaeffer & Budenberg Mfg. Co., Brooklyn, N. Y., exhibited indicating and recording gages and thermometers of their Columbia and Crescent brands; also steam calorimeters and indicating and recording tachometers; chemical thermometers; mercury pressure and vacuum gages; mercurial barometers and gage testers. Their recording apparatus was demonstrated by a complete testing outfit.

Schaum & Uhlinger, Inc., Philadelphia, Pa., displayed photographs and blue-prints of their various types of centrifugals. Messrs. C. W. Schaum and Leslie Griscom were in charge.

Schulte & Koerting Company, Philadelphia, Pa., had a complete working installation of an atomizing spray nozzle for use in acid towers. They also exhibited their Bihns-Jones automatic apparatus for lifting liquids; acid-resisting and reducing valves; spray nozzles; oil firing apparatus and oil and water heaters. Dr. C. Kimberley was in charge.

Scientific Materials Co., Pittsburgh, Pa., had an extensive display of general laboratory supplies, in which the "Scimatico" brands played an important part. Messrs. L. W. Hoshour, T. W. Clark, G. H. A. Binz and J. Seavy were in charge.

Ernest Scott & Co., Fall River, Mass., showed photographs and blue prints of plants and machinery designed and installed by them, especially vacuum and distillation plants. Also samples of apparatus for recovering trade wastes, and some of the products. Messrs. H. Austin and A. B. Kennedy were in charge.

Seydel Manufacturing Co., Jersey City, N. J.—Aniline oils and derivatives; sizings for cottons, woolens, etc.; olive oil soaps.

Sharples Specialty Co., West Chester, Pa., showed their smallest and largest types of super-centrifuges. Principal

interest in these machines is their high speeds, the small one traveling at 40,000 r.p.m. and the large one at 18,000 r.p.m. They are hung from balls and are free at the bottom so that they find their own centers. Samples of some of the Sharples processes, among which were wool fat, glue, cider, crude sugar, benzine, and varnish, showed the machine's wide application.

T. Shriver & Company, Harrison, N. J., showed for the first time a new model of filter press possessing rotary features which perform all of the duties without the need of taking the machine apart. A running test of calcium carbonate was made on this machine during the show. They also exhibited one of their standard plate filters and a filter type oxy-hydrogen generator. Mr. H. D. Atkins was in charge.

Sidio Manufacturing of America, New York City, exhibited a very complete line of American-made fused silica ware for chemical apparatus. Mr. Otto Trautman and S. Herlinger were in charge.

The Solvay Process Co., Syracuse, N. Y., exhibited the various alkalies that they manufacture. In conjunction with this exhibit was that of the Semet-Solvay Co., which showed photographs and blue-prints of by-product coke oven plants which they designed or are operating.

Sowers Manufacturing Co., Buffalo, N. Y., showed Dopp seamless, steam jacketed kettles, mixers and vacuum pans. Messrs. W. Bowman, P. B. Cox and H. H. Blake were in charge.

E. R. Squibb & Sons, New York City, exhibited a general line of reagents. Messrs. Schad & Cary in charge.

Stamford Mfg. Co., New York City, showed furs, silks, woolens, cottons, and leathers dyed with their vegetable dyes. The logwood produces the blacks and blues, the fustic produces the yellows and browns, the hypernic produces the reds, and these are further mixed to produce other shades. Mr. H. G. Stanley was in charge.

Standard Aniline Products, Inc., New York City, exhibited coal tar dyes, intermediates, resins, and other chemicals. Dr. Wallach was in charge.

Stevens-Aylsworth Co., New York City, demonstrated the proper and improper methods of tank agitation. Exhibited sections of their tin, copper, lead, gold and silver-lined apparatus. Messrs. W. N. Stevens, R. G. Stevens and R. P. Aylsworth were in charge.

Stone & Webster Engineering Corp., Boston, Mass., showed several photographs showing industrial and power plants that were designed and constructed by this company. Mr. R. W. Gilbert in charge.

The Stuart & Peterson Co., Burlington, N. J.:—Porcelain lined, steam jacketed kettles, stills, autoclaves, and storage tanks. Messrs. J. J. Kearns and Frank Hearn were in charge.

Sturtevant Mill Co., Boston, Mass., exhibited their crushing, grinding and screening machinery, ring roll mill, "Newaygo" separator, and roll jaw crusher.

Sweetland Filter Press Co., Brooklyn, N. Y.:—The demonstration of this filter press attracted considerable attention as a complete small working filter was in operation. The metallic filter cloth used in conjunction with the press was also a source of much interest. A new trunnion type of filter press for laboratory use was also exhibited. Mr. A. W. Wright was in charge.

Swenson Evaporator Co., Chicago, Ill.:—Working model of a standard Swenson horizontal tube double effect evaporator and samples of some of the materials handled in Swenson evaporators. Messrs. F. M. De Beers, P. B. Sadler, P. H. Appell and H. Perlstein in charge.

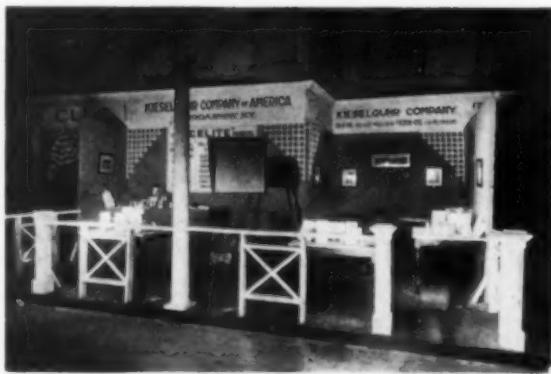
Swiss Colours Co., Inc., New York City, displayed cottons, woolens, silks, furs, leathers, felts and feathers which had been dyed with the products of the American Aniline Products Co. for which they are the selling agents. Mr. B. R. Armour was in charge.

Takamine Laboratory, Inc., New York City, exhibit Polyzine, a diastatic extract, and Newmalt, a substitute for malt extract. Both are American-made. Messrs. Eben Takamine and Jokichi Takamine were in charge.

Taylor Instrument Companies, New York City, exhibited "Tycor" indicating and recording thermometers, pyrometers, oil testing instruments, barometers. Hygrodeik hydrometers, etc. Messrs. H. W. Turner, James Ely, D. C. Day, Jr., N. H. Nelson and Ray Taylor were in charge.

Technical Association of Paper and Pulp Industries maintained a booth for registration of its members during the exposition.

Tennessee Coal, Iron & Railroad Co., Birmingham, Ala., exhibited products of manufactures and samples of the natural resources located along its line, mining camp model and several pictures showing manufactures and the work being carried on by this company in the Birmingham district.



Exhibits at Second National Exposition of Chemical Industries



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Tennessee Power Co., Chattanooga, Tenn.:—Stereopticon views of company's hydroelectric power houses, transmission lines and general equipment. Also views of chemical industries in the power zone. Represented by Messrs. E. A. Hitchcock and C. F. Long.

The Thermal Syndicate, Ltd., New York City:—Complete line of "Vitreosil" laboratory ware and collection of pieces used in various chemical apparatus. Particular interest was noted of a Vitreosil pipe of 15-in. bore and 30 in. long, and condenser pipe of 4-in. bore and 8 ft. 6 in. long. These are the largest pieces ever produced by the electrical fusion of silica. Great interest was shown in resistance of Vitreosil to temperature changes, as illustrated by taking crucibles out of electric furnace at 1000 deg. and plunging them into cold water without breakage occurring. Mr. A. E. Marshall was in charge.

Thwing Instrument Co., Philadelphia, Pa.:—Pyrometers, high-resistance multiple-recording pyrometers, also Duriron and carborundum protecting tubes for thermo-couples. A feature of the company's exhibit was a new type of radiation pyrometer. The exhibit was in charge of Dr. Thwing and Mr. H. K. Walton.

Toch Brothers, New York City, exhibited cement colors, integral waterproofing compound, barium products and chemical dryers. Also had on display finished surfaces and hollow tile showing the quality of their waterproofing paint. Pictures showing many large buildings on which their paints are used were of interest. Messrs. E. A. Marx, F. A. Milligan and S. T. Marcus were in charge.

Tolhurst Machine Works, Troy, N. Y., exhibited each of the following types of centrifugals: Suspended, self-balancing, acid, solid curve and laboratory. They were represented by Messrs. Cady, Gage, Tolhurst, Bryson and Dutton.

Uehling Instrument Co., New York City, displayed a line of fuel economy apparatus, such as Pehling waste meters and carbon-dioxide automatic recording apparatus, draft gages, absolute pressure indicators, draft recorders and pressure recorders. Messrs. F. F. Uehling and S. W. Smith were in charge.

United Cast Iron Pipe & Foundry Co., Burlington, N. J.:—Gray iron castings of unusual shapes and sizes. Also photographs showing various castings in use in industrial plants throughout the country.

United Gas Improvement Co., Philadelphia, Pa., exhibited by-products of coal-gas and water-gas distillation, including intermediates, light refined products, road compounds and pitches. Mr. W. H. Fulwider was in charge.

United Lead Co., New York City:—Lined and covered pipes in lead, tin, brass and copper; Kemetaline. The company also had on exhibit a piece of lead pipe 2000 years old from Rome. This was well preserved and attracted considerable attention. Messrs. L. B. Gallison, O. M. Hoveman, D. F. Miller and C. B. Holden were in charge.

Union Sulphur Co., New York City:—Refined sulphur. Mr. W. N. Wilkinson was in charge.

U. S. Bureau of Census, Washington, D. C.:—Several of its publications and charts showing locations of chemical plants and relative information.

U. S. Bureau of Foreign and Domestic Commerce, Washington, D. C., showed several of its publications and some charts.

U. S. Bureau of Mines, Washington, D. C., showed what the bureau was doing to conserve life in mining operations. Of particular interest was a crew of five dummies, each fully equipped with different types of the latest devices used in rescue work. The development of the extraction of radium from pitchblende and carnolite, of the Georgia clays for white tile and ware, and of the evolution of coal attracted further interest. Mr. M. F. Leopold was in charge.

U. S. Bureau of Standards, Washington, D. C., had a large exhibit showing all of its publications and the apparatus used in its work. This included gas calorimeters and meters, pyrometers, thermometers, hydrometers, standard weights, chemical apparatus and much other material. Of especial interest was a new apparatus for finding the density of a gas by determining its specific gravity, which is found by a method of weighing unequal volumes at different pressures. This apparatus is not yet on the market. Messrs. A. N. Finn, J. D. Edwards and William Blum were in charge.

United States Smelting Co., New York City:—Specimens of products from all of its subsidiary companies, including different brands of copper, lead, spelter, selenium, gold, silver, platinum, palladium, crushed slag, hydrofluoric acid and miscellaneous ores, and an exhibit showing the different stages in the process from ore to refined copper. A small electrolytic cell in operation refining copper proved interesting to the visitors. Messrs. Sidney Rolle and W. C. Smith were in charge.

Universal Fibre Co., Trenton, N. J., exhibited fiber kegs and powder cans.

Valley Iron Works, Appleton, Wis., exhibited two 250-lb. capacity Vesuvius oxidizing sulphur burners, one of which was dismantled for interior inspection. Mr. R. W. Fannon in charge.

Weiller Manufacturing Company, New Brunswick, N. J., exhibited samples of intermediates, nigrisines and colors, and demonstrated by a full-sized installation the manufacture of partraniline. Dr. P. Weiller and Messrs. J. J. White and E. Graf were in charge.

Werner & Pfleiderer Co., Saginaw, Mich.:—Vacuum kneading and mixing machinery, rubber compounding and masticating machinery, laboratory mixing machines, rapid dissolvers. Messrs. Emil Staehle, C. Pletscher, A. J. Vollrath, S. D. Gridley and E. Schiller in attendance.

Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.:—Thury regulating equipment for electrode control (electric furnace equipment), recording instruments, etc. Venturi fan, automatic control panel, motors, float switch, rheostats, special impregnated motor coils, Bakelite, Micarta products. Messrs. O'Neill, Loomis, Lupinski, Ward, Carrier, Gibson, White, Carpenter, Goldsborough, Gerry, Hegarty and W. H. Easton in attendance.

Whitall-Tatum Co., Millville, N. J., exhibited its "Nonsol" glass in beakers and flasks. Reagent bottles and gray and white filter paper. Messrs. W. W. Figgis, E. T. McCane and G. E. Barton were in charge.

Williamsburg Chemical Co., Inc., Brooklyn, N. Y., showed samples of its monochlor benzol, dinitrochlor benzol, dinitrophenol and sulphur black paste and powder. Also exhibited Hydronol of the United Dyestuff & Photochemical Co., Inc., of Brooklyn, which is similar to the German Amidol. Mr. A. H. Cohen was in charge.

Zaremba Co., Buffalo, N. Y., showed interesting photographs of its evaporating apparatus of various designs and sizes. The company had a 180-sq.-ft. single-effect evaporator on display. Mr. Edward Zaremba was in charge.

An Industrial Potentiometer Temperature Indicator

A new indicator operating on the potentiometer principle and designed for use with any thermocouple has recently been placed on the market by the Pyroelectric Instrument Company, of 148 East State Street, Trenton, N. J., a new company which was incorporated in July. Dr. E. F. Northrup of Princeton University is president and technical adviser, Dudley Willcox is treasurer and H. F. Porter, secretary of the new company.

The new instrument, which was on exhibit at the Chemical Exposition is called the pyrovoltmeter. It com-



GENERAL VIEW OF PYROVOLTER

bines the characteristics of the voltmeter, with the accuracy of the potentiometer, and was designed with the purpose of making the readings of temperature independent of the resistance of the thermocouple circuit, which resistance is apt to vary on account of corrosion, temperature conditions, etc.

The pyrovolter, as such, is not the complete measuring outfit but it is the indicator which enables one to read the voltage developed by a thermocouple of any type whatever, whether made of base metals giving a high electromotive force or of noble metals giving a small electromotive force. To adapt the pyrovolter to thermocouples of different combinations of metals and to read to different temperature-elevations, it is only necessary for the maker to choose particular values of certain resistances and to lay off the scale of the instrument for the temperature range which is desired. The deflection instrument employed is exactly the same for all types of thermocouples and for all temperature-ranges and consists of a millivoltmeter of standard make having the strong spring control commonly given to these instruments. The additional features, which permit the electromotive force of a thermocouple to be read independently of the resistance of the thermocouple circuit, consist of a small dry cell, a small rheostat and a switch operated by a push button. These parts, all being small, are located inside the wooden case in which the instrument is mounted. The push button and the handle of the rheostat are outside the case and occupy two front corners. The two ends of the thermocouple are attached to two binding posts located in another corner of the case.

The small dry cell supplies the energy which deflects the instrument, the thermocouple itself not being called upon to furnish any current for the deflection. The rheostat, operated by the handle outside the case, will move the pointer over the scale of the instrument when the handle is turned. By turning the handle until the pointer stands at the beginning of the scale of the instrument and then pushing the button in the left front corner of the instrument the pointer at once deflects to a point on the scale which indicates the true temperature of the fire end of the thermocouple. Anyone can easily prove that this indication is quite independent of the resistance of the thermocouple circuit by connecting in series with the thermocouple a rheostat and adding with this any resistance to the thermocouple circuit from 0 to 50 ohms or more and observing that the temperature indicated is unchanged by this procedure.

As the indications of the pyrovolter do not depend upon the resistance of the thermocouple circuit, it is not necessary to make the thermocouple wires heavy and of large cross-section, as is commonly done for the purpose of keeping the resistance of the thermocouple very low. Thus wires of small diameter may be used and it is entirely practicable to make the thermocouple wires long enough to reach from the fire end to the binding post of the pyrovolter, even when this is 10 or 15 ft. from the fire end. When the thermocouple wires end in the binding posts of the pyrovolter the cold junction of the thermocouple will have the temperature of the instrument and not some much higher and unknown temperature, as when the thermocouple is short and joined by copper leads to the deflection instrument. The pyrovolter is calibrated to read the temperature very correctly when its temperature is 25 deg. C. (77 deg. Fahr.). If when using the instrument the temperature of this, and consequently of the cold junction, is different from 25 deg. C. this fact may be indicated by a small mercury thermometer which is located at one corner of the case of the instrument. The scale of this thermometer is so laid off that its reading indicates the

number of degrees which must be added to or subtracted from the reading of the pyrovolter to give a perfectly correct measurement of the temperature. Thus, if the temperature of the instrument and cold junction is 25 deg. C. the mercury thermometer will read at zero on its scale and there is nothing to add or subtract from the reading. If the temperature of the instrument is higher than 25 deg. C. the mercury thermometer will read some number, as +3 or +4, which number when added to the reading of the pyrovolter gives the true temperature of the fire end. If the instrument and cold junction is below 25 deg. C. the mercury thermometer will read some negative number.

The temperature of the fire end will then be correctly given by subtracting this number from the pyrovolter reading. As at no time this correction will be large, perhaps in an extreme case as much as 10 deg., this mercury thermometer is not added in general for correcting the reading except as an extra feature. When supplied, the indications of temperature are just as accurate as it is possible to read the position of the pointer on the scale of the instrument.

A New Recording Thermometer

The Brown Instrument Company of Philadelphia is placing on the market a new type of recording thermometer for temperatures to 800 deg. Fahr. (425 deg. C.) which embraces a number of original features.



FIG. 1—HELICAL SPRING

This instrument operates on the principle of the expansion of gas with change in temperature. A bulb of copper containing nitrogen gas under pressure is connected to a recording instrument by a small copper tube protected by flexible steel tubing. The recording instrument has a helical spring somewhat similar to that used in pressure gages, and the expansion of the gas in the bulb exerts pressure which is conveyed by the capillary tube to the helix, which expands proportionately.

This helix is directly connected to a recording arm which marks on the record chart.

This type of instrument can be furnished with tubing as long as 100 ft. if required, so that the recording gage can be placed as much as 100 ft. distant from the point where the temperature is measured. This permits of its application in numerous processes where it is desirable to keep a constant record of the temperature on a chart.

Some of the improved features in this new type of instrument follows:

The Seth Thomas clock which revolves the chart is mounted directly on the front plate on which the chart

revolves, which insures alignment of the clock and chart plate.

The clips which hold the chart in position are mounted on the door so that when the door is swung



FIG. 2—RECORDING THERMOMETER

aside these clips are automatically swung away from the chart, permitting its easy replacement without interference.

A device is furnished which raises the chart pen from off the chart automatically when the door is opened, and frees the pen automatically when the door is closed.



FIG. 3—INDICATING THERMOMETER

This instrument is made also in indicating form where desired to indicate the temperature on a dial instead of recording it on a chart.

It is furnished with a number of different types of bulbs, either with threaded connection for insertion in mains and pipes, or with lead coating to withstand chemicals and acids.

Personal

Mr. Merrill G. Baker, assistant sales manager of the American Vanadium Co., Pittsburgh, Pa., has returned from a business trip to Russia.

Officers of the Society for the Promotion of Engineering Education elected at the annual meeting are: President, **G. R. Chatburn**, University of Nebraska; first vice-president, **Hollis Godfrey**, Drexel Institute; second vice-president, **W. M. Thornton**, University of Virginia; secretary, **F. L. Bishop**, University of Pittsburgh; treasurer, **W. O. Wiley**, New York, N. Y.; members of the council to serve for three years, **E. J. McCausland**, University of Missouri; **F. G. Higbee**, State University of Iowa; **R. W. Gay**, Mississippi College; **T. E. French**, the Ohio State University; **A. H. Blanchard**, Columbia University; **A. A. Potter**, Kansas State Agricultural College; **Wm. H. Browne, Jr.**, North Carolina College.

Mr. A. J. Fasbinder, formerly construction engineer at Tampico, Mexico, is now connected with the Carnegie Steel Co., Homestead, Pa., as designing engineer.

Mr. C. E. Georgi, secretary of the Schaeffer & Budenberg Mfg. Co., Brooklyn, N. Y., has been appointed western manager of the company, and is now permanently located at the Chicago office, 427 South Dearborn Street. This appointment was the result of the unexpected and untimely death of the former western manager, Mr. William H. Shenton. Mr. Georgi was formerly New England manager.

Mr. Lyon Smith has resigned as metallurgist for the Snyder Electric Furnace Co. of Chicago, to become assistant superintendent of the River Smelting & Refining Co., Florence, Cal.

Mr. W. H. Staver has removed his office from Lynchburg, Va., to Washington, D. C. He has recently been in Colorado examining property for Boston capitalists.

Notes

The Hydrol Company, Niagara Falls, N. Y., is building a factory for the treatment of oils with hydrogen and the manufacture of artificial paraffine, and is also contemplating the manufacture of dyes from coke by-products to be sent from Pittsburgh.

Duplex Steel Process.—The American Steel & Wire Company has started the manufacture of steel by the Duplex process at its Donora, Pa., plant. A 1300-ton metal mixer was built and installed in the plant by the Pennsylvania Engineering Works, New Castle, Pa., also two 25-ton Bessemer converters, a four-hole soaking pit and there are also eleven 60-ton open-hearth and two 60-ton acid furnaces. The introduction of the duplex process is expected to increase the output of the steel works from 20 to 25 per cent.

The Standard Varnish Works has moved its general offices to the West Street Building, 90 West Street, New York.

Department of Agriculture to Study Dyestuffs.—Co-operation with the manufacturers of dyestuffs will be undertaken by the Department of Agriculture under the \$50,000 appropriation contained in the new agricultural appropriation law. The Bureau of Chemistry of the Agricultural Department will be in charge of the study of dyestuffs manufacture, and is already in communication with manufacturers of dyes and large users of colors. It is a new departure for the Government and its development will be watched with interest. Work will at present be carried on in the laboratories of the Bureau but it is hoped to establish a separate laboratory for dyestuff investigation.